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Author
Chertman, Fernando

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ESSAYS IN INTERNATIONAL FINANCE

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Fernando Chertman

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The Dissertation of Fernando Chertman is approved:

Professor Michael M. Hutchison, Chair

Professor Kenneth Kletzer

Professor Chenyue Hu

Dean Quentin Williams
Acting Vice Provost and Dean of Graduate Studies

Table of Contents

List of Figures

List of Tables

Abstract

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This dissertation studies topics of international finance, such as the use of international reserves as a tool of monetary policies by Emerging Markets (EM), the impact of trade costs in cross-country risk sharing, and the new observed deviations from covered interest rate parity. Each chapter of the dissertation approach one of these three topics.

The first chapter investigates extended Taylor rules and foreign exchange intervention functions in large Emerging Markets (EM), measuring the extent to which policies are designed to stabilize output, inflation, exchange rates and accumulate international reserves. We focus on two large emerging markets - India and Brazil. We also consider the impact of greater capital account openness and which rules dominate when policy conflicts arise. We find that output stabilization is a dominant characteristic of interest rate policy in India, as is inflation targeting in Brazil. Both countries actively use intervention policy to achieve exchange rate stabilization and, at times, stabilizing reserves around a target level tied to observable economic fundamentals. Large unpredicted intervention purchases (sales) accommodate low (high) interest rates, suggesting that external operations are sub-

ordinate to domestic policy objectives. We extend the work to Chile and China for purposes of comparison. Chile's policy functions are similar to Brazil, while China pursues policies that substantially diverge from other EMs.

The second chapter empirically examines whether trade costs impede cross-country consumption risk sharing. Using the data for a large panel of countries over the period 1970-2014, we document that bilateral risk sharing improves once a pair of countries become partners under a regional trade agreement. Moreover, we establish a gravity model of consumption risk sharing by finding that bilateral risk sharing decreases in geographical distance between countries. The effect is more pronounced in the absence of regional trade agreements. These empirical findings support the argument that lifting trade barriers promotes risk sharing across countries.

The third and last chapter examines the deviation from covered interest rate parity. Being a new phenomena observed especially after the 2008 Great Financial Crisis (GFC), we measured the deviations in a cross-country setup, and explored possible causality channels for this behavior. The empirical findings in this chapter show a big heterogeneity of causalities per country, limiting the possibilities of a unified theoretical model to explain it.

To Thais, Rebeca, and Naomi,

my biggest accomplishment.

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Chapter 1

Facing the quadrilemma: Taylor Rules, Intervention Policy and Capital Controls in Large Emerging Markets

1.1 Introduction

The traditional “trilemma” set of policy constraints, where a country needs to balance tradeoffs between degrees of monetary independence, exchange rate stability and controlled capital account openness, has in the recent literature been extended to a “quadrilemma” with a fourth policy goal of financial stability (Aizenman,2017). The later consideration for emerging markets is frequently focused on stability from international financial shocks in the form of sharp movements in capital flows, exchange rate instability and U.S. interest rate fluctuations. Emerging markets have always looked beyond the domestic objectives of inflation and output gaps, emphasized in large advanced economies and embodied in interest rate Taylor Rules, toward external objectives.

In attempting to achieve these external objectives, emerging markets frequently complement policy interest rates with foreign exchange market intervention and capital controls as additional policy instruments. Given that four policy objectives are combined with only three policy instruments (policy interest rate, intervention and capital controls), the "Tinbergen Principle" doesn't hold (i.e. equal instruments and objectives) and policy makers may at times face tradeoffs in achieving all their goals. In this context, the IMF (2012) finds that the number of countries actively managing their exchange rates has increased substantially since the Global Financial Crisis and that Brazil, Chile, Colombia, Turkey, and other emerging markets with announced inflation targeting regimes have increased both the frequency and the size of their interventions. Changes in capital controls are also a powerful macroeconomic management tool in some emerging markets (Fernandez et al., 2015), but are generally used infrequently.

Theoretical work has investigated the tradeoffs associated with domestic and external policy objectives, and where intervention and capital controls may contribute to macroeconomic and financial stability (e.g. Gonçalves (2008), Cavallino (2019), Farhi and Werning (2012), Jeanne (2012)). For example, the theoretical framework of Gonçalves (2008) argues that official accumulation of foreign reserves may be perceived as interventions to influence the exchange rate, undermining the credibility of floating exchange rates and inflation targets. He develops a theoretical framework to study the interaction between reserve accumulation and monetary policy, and highlights the trade-off between the speed of reserve accumulation and anti-inflationary credibility.

In related work, Cavallino (2019) develops a New Keynesian small open economy model that characterizes the optimal use of foreign exchange intervention in response to exchange rate fluctuations driven by capital flows. In his model, an increase in foreign demand for domestic assets appreciates the domestic currency and generates a boom-bust cycle in the economy. In response to such a shock, the optimal foreign exchange intervention in his model is to lean against the wind and stabilize the path of the exchange rate. By leaning against the wind, the central bank reduces the real appreciation (and the consumption boom triggered by the inflow of capital) and reduces the output gap. It is not optimal for the central bank to fully stabilize the exchange rate in this framework since it reduces some of the benefits of portfolio capital flows.

Most empirical work on macroeconomic policy functions, especially for advanced economies, emphasize policy interest rates as reflected in Taylor rules. Taylor rules for emerging markets often recognize external considerations by including an exchange rate stabilization objective, e.g. Aizenman et al. (2011). We extend previous work investigating modified Taylor rules by considering a second policy rule linking foreign exchange market intervention to exchange rate stability and an objective to accumulate reserves to a target level. Specifically, we explore how large emerging-market economies have in practice managed to accumulate substantial reserve levels over time (for precautionary purposes, reducing the likelihood of financial instability), despite substantial cyclical variation, while at the same time following monetary policy rules designed to stabilize inflation, output and the exchange rate.

We focus on two policy instruments, interest rates and foreign exchange market intervention, and four policy objectives—inflation, output, exchange rates and foreign reserve target. Against this background, we also investigate (1) the impact of changes in the intensity of capital controls, though this instrument is only infrequently cyclically applied in most EMs, and the impact of the transmission of U.S. interest rates; and (2) cases of very large discretionary (unpredicted) intervention operations and interest rate changes, evaluating whether the interest rate instrument (internal balance) or intervention operations (external balance) dominate when policy conflicts arise. Although not able to capture all aspects of the quadrilemma with our analysis, we are able to shed light on practical policy considerations for internal and external balance in the use of the two major tools - monetary policy and intervention policy.

Our primary interest is in two large emerging market economies, Brazil and India, with a comparative analysis of the largest EM, China, and one small open economy, Chile. Most theoretical and empirical work in this area focuses on small open economies (SOEs) and attempts to measure where each country lies on a spectrum of policy tradeoffs. However, large emerging markets should display somewhat different characteristics than SOEs in the reserves-exchange rate-monetary policy nexus. In particular, large EM interest rates should not in principle be completely determined by the "center country" (some inherent monetary independence compared with the SOEs) and potential foreign capital inflows are not infinite (as in the SOE model).

Brazil and India use capital controls extensively as a macroeconomic management tool. Although India has been gradually reducing capital controls over the past two decades, it continues to have quite strict international capital controls. Brazil is much more open financially but continues with fairly extensive controls. According to the Fernandez et al. (2016; updated online June 2019) data set on capital control restrictiveness using the IMF Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) as the underlying data source, India and Brazil placed 0.93 and 0.65, respectively in 2017. (The range is from 0 with no restrictions to 1 as completely closed). The authors characterize India with "walls" to external financial flows and Brazil with a "gate." Net liberalization has occurred over the past two decades as corresponding values for India and Brazil in 2000 were 1.0 and 0.85, respectively[1]. (The U.S. had a restrictiveness index of 0.16 in 2017 and 0.13 in 2000 using this methodology). This allows us to explore whether variations in this instrument has impacted the effectiveness of other instrument of macroeconomic management.

These emerging markets have also experienced very large reserve accumulations, motivated at least in part by the desire to reduce the likelihood or severity of financial crises. This fact, in combination with active foreign exchange policies, is an important element of macroeconomic and macro-prudential management. However, their stated macroeconomic policies and monetary regimes are very different. In particular, the Central Bank of Brazil has had an explicit inflation targeting regime since 2001 while the Reserve Bank of India is

[1] China is also characterized by Fernandez et al. (2016) as having "walls" with a capital account restrictiveness measure of 0.85 in 2017 and 1.0 in 2000. Chile is more much more open, with a restrictiveness measure of 0.45 in 2017 (and 0.88 in 2000).

characterized by substantial discretion in policy actions[2].

We empirically evaluate the significance of these regime differences on Taylor rules as well as intervention policy functions, and whether capital controls influence policy actions and the transmission of U.S. interest rate changes to policy rates. We also consider whether interest rate policy (internal balance) dominates or is subordinate to intervention policy (external balance) when policy conflicts arise. We use time-series methods for our methodology and employ quarterly data. Additional features of our analysis are the incorporation of a measure of "adequate" reserves, calculated by the IMF, into our intervention equation, and a measure of capital account openness, based on the work of Pasricha et al. (2015) and Pasricha (2017), into the interest rate rule (Taylor rule) and intervention rule equations.

We include China in our study as a counterpoint to the other large EMs. As China's institutions are quite different, it is an interesting comparison case. And, as a counterpart to our analysis of large emerging markets, we also consider a small commodity-based emerging market - Chile. Chile is a small open economy, largely commodity-based and with very open capital markets. We investigate whether the revealed policy choices for large emerging markets carry over to small emerging markets like Chile. The remainder of the paper is organized as follows. Section 2 presents some background on macroeconomic management and external considerations in Brazil and India. Section 3 presents the basic model. Section 4 presents data and methodology. Section 5 presents the empirical results for Brazil and India. Section 6 extends the analysis to China and Chile. Section 7 concludes.

[2]Chile also has an inflation targeting regime, while the People's Bank of China monetary policy demonstrates substantial discretion.

1.2 Macroeconomic Management in Large Emerging Market Economies

Our focus emerging markets - India and Brazil- have experienced challenges to macroeconomic and financial stability similar to other emerging markets and advanced economies. Managing domestic output and inflation objectives in tandem with exchange rate and balance of payments stability has frequently been a balancing act between multiple targets and limited policy instruments. Neither of these countries explicitly state that they follow a Taylor rule in setting interest rates, but in monetary policy statements note that inflation is a priority and usually point to the state of the economy as a consideration in setting policy. Our objective is to quantify the relative importance of these factors. Similarly, authorities rarely provide an explicit intervention policy guide but ex post policy statements often refer to “disorderly” exchange market conditions, reserve and current account developments, and so forth in explaining their actions. Again, our objective is to quantity, if possible, the relative weight that these various considerations play in systematically influencing intervention operations. Previous research and policy statements help guide us in our empirical specifications.

In particular, the Reserve Bank of India formally states that its primary objective is to maintain price stability, while “...keeping in mind the objective of growth” and announced recently a “flexible inflation targeting” regime[3]. Empirical work has found that

[3] The Reserve Bank of India (July 2019) states that the goals of monetary policy are:

“The primary objective of monetary policy is to maintain price stability while keeping in mind the objective of growth. Price stability is a necessary precondition to sustainable growth.” Moreover, in May 2016, the Reserve Bank of India (RBI) Act, 1934 was amended to provide a statutory basis for the implementation of

India alternates between an emphasis on output and inflation in pursuing domestic macroeconomic stability (Hutchison et al. 2013; Gupta and Sengupta, 2014; Kaur, 2016), and maintaining orderly conditions in the foreign exchange markets as an official objective of the Reserve Bank of India (RBI) (Hutchison and Pasricha, 2016). RBI is the manager of the foreign exchange regulation act (FEMA, 2004), which also gives it the power to impose capital controls. In practice, this objective has meant very active management of controls on international capital movements and frequent foreign exchange market intervention operations, as well as at least one episode (in 2013) of interest rate defense of the exchange rate. These considerations make understanding the linkages between monetary policy, capital controls and foreign exchange market intervention operations central to a study of macroeconomic management in India.

Hutchison and Pasricha (2016) find that India has followed active foreign exchange market intervention and capital control policies. They argue that intervention policy is mainly directed toward limiting exchange rate appreciation, during which times dollar purchases were generally large, and not directed toward limiting depreciation. This policy may have allowed relative stability in the real exchange rate, hence maintaining India export competitiveness, as the exchange rate depreciated over longer-periods to offset relative high inflation in India. Intervention policy and exchange rate depreciation also allowed greater monetary autonomy, especially during a period associated with increased financial liberalization of the international capital account. Moreover, reserve accumulation—through USD purchases on the foreign exchange market—is a desirable objective to the extent that it provides a stock of precautionary reserves in the event of a balance of payments/currency crisis

the flexible inflation targeting framework.

or sudden stop in private capital inflows that generally finance persistent current account deficits in India. On the other hand, the exchange rate has not been a "nominal anchor" for monetary policy in India, and as a consequence high inflation is a recurring problem.

Control of international financial capital movements is another policy instrument that has been frequently employed to influence financial flows in and out of India and the exchange rate (Hutchison et al. (2012); Patnaik and Shah, 2012; Hutchison and Pasricha, 2016). Although the overall trend was towards financial liberalization of the capital account, capital control actions (i.e. tightening and easing of restrictions on capital flows) have been actively used as an instrument to "lean against the wind" of exchange rate pressures in both directions. Whether or not capital controls policies have been effective is evaluated by Patnaik and Shah (2012).

Similar, tradeoffs between domestic and external objectives have also confronted the Central Bank of Brazil. The country is the largest emerging market to adopt an inflation targeting regime (IT), starting in July 1999 and formally continuing to date. Cortes and Paiva (2017) argue that the Central Bank of Brazil (BCB) succeeded in anchoring inflation expectations and gaining credibility until 2011, when a new discretionary-based policy was adopted despite a formal IT rule. However, it is evident from numerous policy statements that output stabilization is also an important element in setting interest rate policy in Brazil. Minutes from a recent monetary policy report from the Central Bank of Brazil (2019), for example, note that: "The Copom members assessed that economic conditions with anchored inflation expectations, underlying inflation measures at appropriate levels, 2020 inflation projected around or slightly below target, and high *level of slack in the economy prescribe* *stimulative monetary policy*, i.e., interest rates below the structural interest rate level. The structural interest rate is a reference for the conduct of monetary policy"[4]. Hence, in this case it is also of interest to measure the weights the central bank places on the inflation target as opposed to output stabilization and other factors in setting interest rates. Other factors may include the exchange rate. For example, Aizenman et al. (2011) find that commodity-based emerging markets with an IT regime such as Brazil are still very likely to smooth exchange rates as part of their Taylor Rule interest rate setting policy.

The Central Bank of Brazil also intervenes in the foreign exchange market to smooth excessive exchange rate volatility and to manage the level of international reserves (Gnabo et al., 2010). Although intervention activity varies over time, waning in recent years, spot-market interventions and the sale of exchange swaps are predominantly against the wind in terms of USD. In terms of the effectiveness of intervention, several studies find that FX intervention, including through swaps, can affect the exchange rate, e.g. Kohlscheen and Andrade (2014), Barroso (2014), Chamon et al. (2017), and Oliveira and Novaesk (2007). Oliveira and Novaesk (2007), for example, find that in periods of relative tranquility the level of the exchange rate is affected more strongly by interventions (in both the spot and the derivatives markets) than the stance of monetary policy, while interventions appear ineffective during episodes of high exchange rate volatility.

[4]Minutes of the 223rd Meeting of the Monetary Policy Committee (Copom) Banco Central do Brasil, June 18-19, 2019. Italics in the quote are our own.

1.3 Model

The basic analytical framework consists of two policy rules: a modified Taylor rule and a foreign exchange intervention policy function. Policy is directed toward achieving two domestic objectives, output and inflation stabilization, and two international macroeconomic objectives, exchange rate stabilization and a target level of international reserves to reduce the risk of capital stops and financial instability. Two instruments are associated with policy functions, and one instrument, fluctuations in capital controls, is taken as a pre-determined variable. In addition to the two policy reaction functions, foreign exchange market is directly linked to changes in international reserves through an accounting identity.

The Taylor rule is modified to capture the central bank's objective of reducing output variations around trend, inflation variations from target, and stabilize the nominal exchange rate. Given hysteresis found in policy actions we include a lagged interest rate as is standard in most studies. The modification of the Taylor rule to include an exchange rate target is standard in the emerging markets literature (e.g. Aizenman et al., 2011). This formulation takes the form:

$$i_t = \alpha_1 + \alpha_2(y_t - y^*) + \alpha_3(\pi_t - \pi^*) + \alpha_4(e_t - e_{t-1}) + \alpha_5 i_{t-1} + \varepsilon_t \tag{1.1}$$

where i_t is the central bank interest rate operating instrument, $(y_t - y^*)$ is (log) output less (log) output trend (i.e. percentage deviation from trend output), $(\pi_t - \pi^*)$ is inflation deviation from target, $(e_t - e_{t-1})$ is the (log) nominal exchange rate change, and ε_t is the error term. Stabilizing objectives ("leaning against the wind") of output, inflation and the exchange rate suggests that $\alpha_2 > 0$, $\alpha_3 > 0$, and $\alpha_4 > 0$.

The foreign exchange management fund is postulated to intervene in the foreign exchange market (foreign exchange purchases are positive values) to stabilize the exchange rate and to manage foreign reserves around the target level. Hence, there are potentially two instruments focused on exchange rate management. In addition, the target level may itself vary over time as suggested by the very rapid buildup of international reserves by emerging market economies during the period prior to the Global Financial Crisis (GFC). The intervention equation takes the form:

$$I_t = \beta_1 + \beta_2(e_t - e_{t-1}) + \beta_3(R_t - R_t^*) + \mu_t \tag{1.2}$$

where I_t is foreign exchange market intervention (USD purchases (purchases of foreign exchange are positive values and sales are negative values, as a percent of last quarter's stock of international reserves), $(R - R^*)$ is the (log) stock of international reserves less the (log) of the target reserve level (i.e. percentage deviation from target reserves) and μ_t is the error term. Foreign exchange sales intervention to slow exchange rate depreciation $(e_t - e_{t-1} > 0)$ suggests $\beta_2 < 0$. A rise in the stock of reserves above the target value also suggests foreign exchange sales intervention, $\beta_3 < 0$.

Intervention is linked to international reserves through an accounting identify, i.e. the rise (fall) in international reserves equals foreign exchange intervention purchases (sales) plus interest earnings on foreign reserves and valuation changes:

$$R_t - R_{t-1} = I_{t-1} + i_{t-1}^* R_{t-1} + VAL_{t-1} \tag{1.3}$$

where i_{t-1}^* is the interest rate on foreign exchange reserves and VAL_{t-1} is valuation changes on international reserve holdings. Hence, intervention is directly linked to the target for international reserves. Our assumption is that i_{t-1}^* and VAL_{t-1} are exogenous variables.

As extensions of the basic models represented by equations (1) and (2), we also include the terms-of-trade and the current account in both equations. A rise in either the terms-of-trade or the current account have wealth and liquidity effects on the economy and could elicit a monetary response. Similarly, a terms-of-trade change could impact the foreign exchange market (increasing foreign exchange receipts), as could a rise in the current account by increasing liquidity in the market. Both of these variables also have proved important in other studies of macroeconomic policy in EMs (e.g. Aizenman et al. 2011).

We also investigate the extent to which U.S. interest rates (i_t^*) and capital account openness ($openness_t$) constrain domestic interest rate policy (Taylor rule) and, for ($openness_t$), enters into decisions to intervene in the foreign exchange market. We would expect U.S. interest rates to enter directly into interest rate policy decisions, in addition to the indirect channel via the exchange rate, especially in the post-GFC period when greater movement of international capital was generally allowed in both Brazil and India. The effect of greater capital market openness (liberalization) on both interest rate and intervention policies would depend on the directional response of net private capital flows, which in turn on market conditions and whether institutional measures liberalized controls on inflows or outflows.

1.4 Data and Methodology

1.4.1 Data

We employ quarterly data over the period 1999q1-2018q4 in our analysis. The exact sample period varies slightly between regression specifications due to data availability. Descriptions of each variable and the date range over which they are available are explained in the appendix[5].

Macroeconomic developments for both countries are detailed in the summary statistics of Table 1 and Figures 1-7. Panel A of Table 1 shows the full sample period, Panel B shows the pre-GFC crisis sample period and Panel C shows the post-GFC crisis period. India generally has a much more stable macro-economy than Brazil, with lower interest rates, lower inflation and more stable (lower standard deviation) exchange rates, intervention and reserves (relative to "adequate" reserves)[6]. Figure 1 shows the output gap; Figure 2 inflation (and, for Brazil, evolution of the inflation target); Figure 3 money market interest rates; Figure 4 exchange rates (left panel, level of the domestic currency per USD; right panel, percent change); Figure 5, left column, is the level of international reserves and the "adequate reserves" level (estimated by the IMF) and the right column is the net spot

[5]Two appendices - sources of data and detailed variable definitions - are omitted from the text for brevity but are available from the authors upon request.

[6]It is an intriguing question as to why Brazil has had a much more volatile economy than India, with prime candidates more restrictive capital controls in India and, hence, less volatile capital movements; more volatile external shocks in Brazil associated with dependence on commodities and terms-of-trade fluctuations; and so on. Our focus is not in addressing this issue but to compare monetary and intervention policies in the two countries. Differences in policies, however, may play an important role in explaining relative volatility of these economies.

foreign exchange market intervention; Figure 6 is the reserve gap (difference between actual reserves and adequate reserves as a percent of adequate reserves; Figure 7 is the measure of cumulative step of external capital account openness (cumulative net changes).

We use a standard measure of the output gap given by the cyclical deviation of industrial production from its trend. We seasonally adjusted both series using the U.S. Census Bureau X-13 procedure. HP filter estimates of the logged series are employed to obtain trend and cyclical output measures. The cyclical portion is multiplied by 100, yielding an output gap measure that can be interpreted as the percent deviation of industrial production from its trend level. The output gap measures are shown in Figure 1. This series has been employed in other studies investigating monetary policy in both Brazil and India. (Kaur, 2016; Gupta and Sengupta, 2014; De Almeida, 2003). It is evident from the figure that output gap volatility has been much larger in Brazil than India.

As noted, Brazil has had an inflation target since 1999. This target has changed several times over the sample period, shown in Figure 2, but for most of the sample the midpoint target was 4.5%. India does not have an announced inflation target. For purposes of econometric estimation, we assume the target is constant and therefore subsumed in the constant term of the estimated Taylor rule for India. We follow other studies (e.g. Gupta and Sengupta, 2014; Modenesi et al., 2013) and use the WPI index to construct the inflation rate in India and the IPCA index for Brazil. Inflation averaged 4.7% in India and 5.2% in Brazil over the sample period, with similar volatility, shown in Table 1. Brazil has been slightly above its inflation target over the sample period (0.4% above).

Money market interest rates are employed in both studies, shown in Figure 3.

Despite similar inflation rates, Brazil has almost double the nominal (and real) interest rates than India. This may reflect both real growth equilibrium factors (determining equilibrium real interest rates), risk premium differences, institutional features of the two economies, and that Brazil is more financially open. The stance of monetary policy is measured with the money market interest rate. For India, this is the 3-month interbank lending rate. For Brazil, we use the SELIC rate, which is the overnight interbank lending rate. The nominal exchange rate employed in the study, shown in Figure 4, is the value of local currency against the USD. Brazil has experienced higher average depreciation (1.0% quarterly average) over the sample than India (0.7% quarterly average), shown in Table 1, and much higher exchange rate volatility.

Foreign exchange market intervention is defined as foreign currency purchases (domestic currency sales) in the foreign exchange market, valued in millions USD, shown in the right panels of Figure 5. This data is obtained from the Central Banks of Brazil and India, respectively. Negative values represent foreign currency sales (domestic currency purchases) in the foreign exchange market. The advantage of this measure is that it only reports active intervention in the foreign exchange market and excludes interest earnings and valuation effects on reserves. (Many studies proxy intervention by changes in reserves). Both countries actively intervened in the foreign exchange market during most of the sample period, though Brazil ceased its intervention activity in recent years.

Reserves are defined as international reserves less gold but including SDRs, shown in the left panels of Figure 5. Reserve data for Brazil and India are obtained from the central bank of each country. No reserve targets are announced in either country. As a proxy, we use the IMF series on reserve adequacy for both Brazil and India. The IMF defines international reserve adequacy (RA) for emerging market economies with floating exchange rates as $RA = (5\% \times \mathit{Exports}) + (5\% \times \mathit{Broad\ Money}) + (30\% \times \mathit{Short\ Term\ Debt}) + (15\% \times \mathit{Other\ Liabilities})$. The IMF measure of reserve adequacy is only available at the annual level. An approximate quarterly series is estimated using a cubic spline interpolation. The resulting quarterly series are also plotted in the left panels of Figure 5. It is apparent that both countries grew reserves very substantially since the early 2000s, pausing at the time of the GFC. After that period, reserve growth in reserves continued in India and flattened out in Brazil.

The reserve "gap," measured by the difference between actual reserves and reserve adequacy (as a percentage of reserve adequacy), is shown in Figure 6. This figure shows that India exceeded its "reserve adequacy" metric from around 2002, peaking at almost 100% just before the GFC. Since that time, the reserve gap declined before stabilizing at about 30%. Brazil's reserve gap was negative until 2007 but has been consistently positive since 2010, fluctuating around 50% from 2014 until 2018.

Capital Openness Index, shown in Figure 7, is taken by accumulating net capital account liberalization or restrictiveness changes based on the Pasricha et al. (2015) dataset, updated in Pasricha (2017). This is a dataset of capital control actions for 16 emerging market economies, where country-level measures of capital control changes are based on a weighted sum of the capital account changes for a given year, where the weights are given by the share of the country's international investment position that are affected by the policy change. We take the cumulative sum of these changes so that they can be interpreted as the level of capital openness for a given country, albeit not comparable across countries in level form. The resulting time series for Brazil and India is shown in Figure 7. This index has been used in Pasricha et al. (2015), Pasricha (2017), and Aizenman and Binici (2016). Some of the advantages of this series are that it results in a measure of capital openness that varies more regularly than several measures such as the Chinn-Ito index (Chinn and Ito, 2006) or Fernandez et al. (2016). This is because it presumably takes into account all regulatory changes for a given country and weights them according to their estimated impact on capital flows.

1.4.2 Methodology

Turning to methodology, our baseline time series models for Brazil and India are estimated over the 1999q1-2018q4 period. We allow for sample shifts before (1999q1-2008q4) and after the Global Financial Crisis (2009q1-2018q4), as the external environment changed markedly at this time, likely impacting policy behavior. We employ a methodology that considers the endogeneity of the reserve gap. The contemporaneous reserve gap is influenced by the scope of intervention operations. Consequently, we treat the reserve gap variable as endogenous and instrument for it with its lagged value. Exchange rate fluctuations are likely to suffer from a two-way causality issue as well. However, we do not employ instrumental variables for the exchange rate. There are two reasons for this decision. First, exchange rates are notoriously difficult to predict and thus finding a strong instrument is a daunting task. Weak instruments lead to results that perform poorer than OLS estimates (Stock, Wright, and Yogo 2002), and it isn't clear that instrumenting for the exchange rate leads to improved estimates. The second reason is that the bias of the exchange rate coefficient works against our hypothesis. This is because lower interest rates and foreign currency purchases lead to exchange rate depreciation, whereas we expect depreciation to cause higher interest rates and purchases of domestic currency. Our results for the exchange rate can therefore be interpreted as a lower bound on the true effect of exchange rates on interest rate and intervention policy. Both inflation and the output gap are assumed to respond to interest rate changes only with a lag and are treated as pre-determined variables. We estimate HAC Newey-West standard errors to account for potential autocorrelation and heteroscedasticity in the error term.

1.5 Results

1.5.1 Baseline and Extended Full Sample Results

Table 2 shows the full-sample baseline results for Brazil and India (column 1), together with the extended model including the terms-of-trade and the current account (column 2). Panel A reports the extended Taylor rule model estimations and Panel B the intervention functions. Spot intervention operations are employed in the intervention function estimates reported in Panel B[7].

The results shown in Panel A indicate very different monetary policies pursued by India and Brazil over the full sample period. India has systemically pursued output stabilization, raising domestic interest rates on average by 11 basis points in response to a one percentage point rise in the output gap. We find no evidence that the Reserve Bank of India systematically responds to inflation or exchange rates in setting money market rates

[7] We also considered a measure of intervention aggregating spot and forward transactions. The results were unchanged, omitted for brevity, and are available from the authors upon request.

over the full sample period. Brazil, on the other hand, responds strongly to deviations from its inflation target, confirming the central bank's commitment to an IT regime, increasing the interest rate by 60 basis points for every 1 percentage point above the inflation target. The extended results also suggest that the Central Bank of Brazil responds to exchange rate depreciation by raising interest rates. In sharp contrast with India, no output stabilization by Brazil's central bank is indicated over the full sample.

The additional variables (terms-of-trade and current account) of the extended model do not appear significant for India, but the terms-of-trade does enter significantly for Brazil. An improvement in the terms-of-trade in Brazil is associated with a (statistically significant) decline in interest rates. Interest rate policy is highly persistent in both countries, especially in India (lagged dependent variable coefficient equals 0.81-0.82 in India and 0.65-0.66 in Brazil).

Although following quite different Taylor rules, India and Brazil are similar in foreign exchange market intervention policy responses to exchange rate changes, shown in Panel B of Table 2. Both countries respond strongly to exchange rate movements in "leaning against the wind" intervention operations, selling (buying) about 0.17-0.22% in Brazil and 0.30-0.48% in India, of the stock of international reserves in response to a one percent depreciation (appreciation) of the domestic currency against the USD.

Only India appears to systematically target reserves around a level associated with observable economic fundamentals. A rise (fall) in actual reserves above (below) the target induces a significant sale (purchase) in foreign exchange (as a percent of last period's total reserves)[8]. Differences also emerge between the two countries in terms of responses

[8]This result is statistically significant in the baseline model at the 1% level, but not statistically significant

to terms-of-trade fluctuations and the current account. A terms-of-trade improvement in Brazil reduces U.S. dollar intervention purchases - most likely attributable to higher foreign exchange earnings for Brazilian exports. No intervention response is noted to changes in the current account in Brazil. By contrast, the current account is estimated to be highly significant for intervention policy in India, with a rise in the surplus (as a percent of GDP) leading to a significant increase in U.S. Dollar purchases, perhaps absorbing excess liquidity generated by the surplus in the foreign exchange market in the face of fairly restrictive capital controls. Although the exchange rate response remains significant in Indian intervention policy, albeit weaker than in the basic equation, targeting of reserves is no longer statistically significant (although the coefficient estimate is very similar, it is measured with less precision).

It is noteworthy that both India and Brazil built very substantial foreign exchange reserve positions during the sample period. This is reflected in the empirical model by the significant positive constant terms in the intervention regressions, indicating substantial average foreign exchange purchases (as a percentage of existing reserves).

1.5.2 Policy Shifts and the Global Financial Crisis

We address whether policy shifts occurred at the time of the GFC in Table 3, comparing the pre-GFC 1999Q1-2008Q4 period with the post-GFC 2009Q1-2018Q4 period. We present both the baseline model and the extended model in Table 3, but focus our discussion on the extended model results.

The full sample results on output and inflation carry over to the sub-sample re-

in the extended model.

sults—during both sub-samples India focused on output stabilization and Brazil focused on inflation targeting. Nonetheless, we find some evidence that India began responding to inflation deviations in the post-crisis period[9] and also to terms-of-trade changes in both pre- and post-crisis samples. The current account is only statistically significant for India in the pre-crisis sample.

As stated, inflation targeting dominated the Central Bank of Brazil's interest rate policy in both sub-periods, as it did in the full sample period, but the estimated response is weaker in the post-GFC period[10]. This finding sheds some light on the concern that Brazil is adhering less to inflation targeting in recent years (Cortes and Paiva, 2017). However, no output response is estimated in Brazil in either sub-period, nor is there evidence of systematic responses to exchange rates, terms-of-trade or current account movements.

Exchange rate stabilization is a dominant feature of intervention policy for India in the pre and post-GFC, with quite similar responses, as for the full sample period. All the coefficient estimates are significant at the 5% level or better. By contrast, the estimates for the two sub-samples in Brazil are not statistically significant (unlike the full sample).

Stronger responses are suggested in the management of foreign exchange reserves in India from the pre to the post-GFC[11], and the response in the latter period - selling foreign exchange when reserves are above target - is consistent with a stabilizing role. The response for the reserve gap is significantly negative in Brazil both periods, with policy

[9] The coefficient is 0.04 (not statistically significant) for the early period and 0.03 (statistically significant) for the later period. The difference in coefficient values is not statistically significant.

[10] However, this difference in coefficient estimates is not statistically significant at conventional levels (z-statistic 0.96).

[11] The z-statistic measuring differences in coefficient estimates is 2.53 (significant at the 5% level).

targeting a desired reserve level, and the coefficient estimates are similar. The terms-of-trade played a role in intervention policy for both countries in the pre-GFC period, but not in post-GFC period. A rise in the current account surplus induced USD purchases in both periods for India, probably to absorb surplus liquidity in the foreign exchange market and limit pressure on the Rupee to appreciate in the face of capital controls. Surprisingly, the opposite result is obtained (negative and statistically significant) for Brazil in the post-GFC period.

1.5.3 Transmission of U.S. Interest Rates and Capital Controls

In this section we explore the extent to which policy interest rates in India and Brazil are directly tied to U.S. interest rates in addition to the indirect link via the exchange rate. We also consider the impact of external financial account openness on policy interest rates and foreign exchange market intervention policy.

The results are reported in Table 4. U.S. interest rates did not move enough during the post-GFC, encompassing the zero-lower-bound period, to warrant inclusion in the sample so only the pre-GFC period is presented in our Taylor rule equation estimates. Column (1) in Panel A for India and Brazil include the U.S. interest rate in the baseline Taylor rule regression, while column (2) reports estimates with the U.S. interest rate and openness. The estimates indicate that domestic money market rates move about 18-27 (Brazil) to 24-25 (India) basis points for a 1 percentage point move in U.S. interest rates, though only the estimates for India are statistically significant.

The results in Table 4 suggest quite different policy responses to capital account liberalization in India and Brazil. For India, in the pre-GFC period, an increase in openness led to lower money market interest rates (8 basis points, Panel A) and sales of foreign exchange (0.97 percent of reserves) by the central bank (Panel B). No significant impact on intervention policy from greater openness is seen in the post-GFC. In Brazil, steps toward greater openness (restrictiveness) also is associated with lower (higher) domestic interest rates (61 basis points), but prompted the purchase of foreign currency by the central bank in the pre-GFC (6.17 percent of reserves) and sales of foreign currency in the post-GFC (1.5 percent of reserves).

These differences may be explained in part by how the pattern of financial market liberalization/openness and market conditions affected net capital flows in the two periods and across the two countries, leading to varying policy responses. Shown in Figure 7, India—though much more financially closed generally than Brazil—set out on a gradual process of external financial liberalization over the sample period. The number of liberalization measures (positive steps in the figure) far exceeded the number of restrictive measures (negative steps in the figure), so that over 50 net liberalization steps were taken between 2001 and the end of 2015. Brazil, on the other hand, used capital control more as a cyclical policy instrument, at times loosening and at times tightening controls. The number of net liberalization steps (positive) only slightly outnumbered the number of restrictive (negative) steps over course of the full sample.

For India, it appears that a rise in openness led to net capital outflows in the pre-GFC, perhaps because of a tendency to liberalize outflows more than inflows, indirectly creating incipient pressure for currency depreciation, and in turn prompting the central bank to "absorb" the impact on the foreign exchange market by selling foreign exchange (an official capital inflow). Less private capital inflow may also have adversely impacted domestic investment, leading the Reserve Bank of India to respond by lowering the policy rate. The effect of liberalization of inflows and outflows may have been more balanced post-GFC as no impact on intervention operations is found.

The results for Brazil, on the other hand, suggest that an increase in openness led to a surge in net private capital inflows during the pre-GFC period, leading the central bank to offset the impact on the foreign exchange market by making large USD purchases. The capital inflow associated with greater openness during pre-GFC was also associated with lower money market rates, suggesting that the central bank allowed private capital inflows to loosen domestic financial market conditions. The contrasts with post-GFC, where a net increase in openness was associated with net capital outflows and official sales of foreign exchange reserves. Liberalization in this period may have been more directed to relaxation of controls on outflows than inflows or attributable to adverse market conditions.

1.5.4 Linkage across policies

Tradeoffs between interest rate and intervention policies are not explicitly addressed using our basic methodology. It is possible that "errors" in one policy function, i.e. deviations from predicted values, are discretionary policy actions connected to the second policy function. For example, unexpectedly low interest rates (intervention) may be linked to unexpectedly low intervention (interest rates) as authorities are attempting to manage the exchange rate via the Taylor rule rather than direct intervention operations. In other words, there may be tradeoffs and substitutions between the internal and external policy functions that are manifested in the error terms.

We address this issue in two ways. Our first approach is to estimate the two equations using a Three Stage Least Squares (3SLS) systems estimator[12]. This method takes into account systemic linkages among the errors of the two policy equations while also accounting for the endogeneity of the reserve gap in the intervention equation. The estimates, not reported for brevity are virtually identical to the extended model results reported in Table 2, column 2 for both India and Brazil's interest rate (Panel A) and intervention (Panel B) policy equations[13]. This indicates that the error terms in the two equations are not significantly correlated in a simple way. This is confirmed by the simple error correlations across the two equations– statistically insignificant correlation coefficients of -0.16 (standard error 0.11) for India and 0.02 (standard error 0.11) for Brazil.

We also explore possible linkages between large policy errors in the two equations since policy tradeoffs or conflicts may only be manifested during particular episodes. For example, a country may not respond to substantial pressure on the exchange rate in the Taylor rule if domestic conditions are clearly not warranting an interest rate change, placing greater emphasis on intervention policy. We identify the intervention policy errors (interest rate policy errors) that are equal to or larger than the 90th percentile in absolute value and regress these on the associated interest rate policy (intervention policy) function errors in Table 5. These results indicate that the equations are related in a highly non-linear way. In particular, large intervention policy errors in both India and Brazil are negatively and

[12]Greene (2012) shows that the seemingly unrelated regressions model, estimated equation by equation, is inefficient compared with an estimator that makes use of the cross-equation correlations of the disturbances. Following Greene (2012), we estimate both equations jointly with a three-stage least squares estimator (the IV estimator is simply equation-by-equation 2SLS). This procedure is asymptotically efficient.

[13]These results are available from the authors upon request.

significantly correlated with corresponding interest rate policy errors. That is, unexpectedly large USD purchases (sales) by the foreign exchange fund are associated with lower (higher) than predicted interest rates. This suggests that episodes of especially large unexpected intervention purchases/sales may be designed to limit the need for interest rate changes in macro policy management. Interestingly, we do not find that large interest rate errors are correlated with associated intervention errors[14]. Discretionary intervention policy actions appear to serve as a "pressure valve" when policy conflicts arise, subordinate to interest rate policy.

1.6 Robustness: Extensions to China and Chile

In this section we contrast our results for Brazil and India with two other emerging markets, Chile and China. The contrasts between Chile and China are stark. Chile is a small open economy with inflation targeting, high dependence on commodity exports, flexible exchange rates and a very open capital account. China, on the other hand, is the largest emerging market—the second largest economy in the world after the United States—with discretionary monetary policy, dominance of manufacturing exports, rigid exchange rate and largely closed to (non-FDI) external capital flows. China is also characterized by heavy government involvement in the financial sector, government majority ownership in large banks, and regulated interest rates.

Chile is included to check the robustness of the results to a small open market-oriented EM with high dependence on commodity exports and a policy commitment to

[14] Not reported for brevity but available from the authors upon request.

inflation targeting. China, of course, is the obvious choice to include in our study due simply to its importance to the world economy, rapid growth and buildup of international reserves. It is not a country of emphasis in this study, but rather an extension of our work, because China's macroeconomic institutions differ so markedly from other large EMs.

1.6.1 Chile

Chile was the second country in the world to adopt inflation targeting (IT), setting its first annual target in September 1990, and IT was used as a device to bring inflation gradually down to a stationary 3% level (Schmidt-Hebbel and Tapia, 2002). As noted in its 2019 monetary policy report:[15] "The main objective of the Central Bank of Chile's monetary policy is to keep inflation low, stable, and sustainable over time. Its explicit commitment is to keep annual CPI inflation at around 3% most of the time, within a range of plus or minus one percentage point."[16] Although the main objective of policy is focused on inflation, it does not preclude secondary objectives and several articles suggest that both internal and external factors may play a role in determining domestic interest rates (e.g. Edwards, 2015). Navdon and Vial (2016), for example, emphasize the impact of commodity prices and the exchange rate on inflation in Chile. Nonetheless, monetary policy statements from the central bank generally do not refer to output stabilization as a reason for policy changes.

[15] Monetary Policy Report, June 2019, Central Bank of Chile.

[16] This quote continues to state that output stabilization is a derivative of achieving stable inflation, but not an explicit objective of policy: "Low, stable inflation promotes economic activity and growth while preventing the erosion of personal income. Moreover, focusing monetary policy on achieving the inflation target helps to moderate fluctuations in national employment and output."

Table 6 shows the empirical estimates results for Chile. Panel A indicates that over the full sample period interest rate policy responded significantly in the expected ways to both inflation and the output gap. But the estimates suggest that greater focus in Chile was on inflation targeting in the pre-GFC period and on output targeting during the post-GFC period[17]. In the pre-GFC period, improvements in the terms-of-trade (and associated wealth gains and improving economy) were associated with interest rate hikes. Rising current account surpluses, in tandem with increased financial market liquidity, led to nominal interest rate declines. No statistically significant responses to either the terms-of-trade nor the current account were found in the post-GFC period, reflecting in part a low and largely unchanged policy interest rate during this period[18].

Panel B of Table 5 indicates that Chile's intervention policy targeted the reserve gap and was also impacted by the current account (with official purchases of USD declining

[17]These differences are statistically significant. The z-statistic measuring the significance of the difference in the output gap (inflation target) is -2.60 (1.74), significant at the 1% (5%) level.

[18]These differences are statistically significant. The z-statistic for the difference in coefficients on the terms-of-trade (current account) between the two periods is 2.83 (-2.40), significant at the 1% (5%) level.

with a rise in the surplus) during the post-GFC[19,20]. There is no systemic evidence of intervention policy directed towards exchange rate management in the full sample period or either sub-sample.

1.6.2 China

Analyzing monetary policy in China is not straightforward as the People's Bank of China (PBoC) uses more than one instrument for monetary policy and these instruments have evolved over time (Chen et al., 2017). The PBoC currently uses seven instruments of implementation of monetary policy, including the rediscount rate on loans to banks and other benchmark interest rates.[21] Moreover, stronger emphasis has been placed on targeting interest rates as the major monetary policy instrument in recent years (He and Jia, 2019). Given China's extensive use of capital controls and direct involvement in the banking sec-

[19] We do not have central bank data on intervention for Chile and China (as we do for India and Brazil). We proxy for intervention by the change in international reserves, adjusted for interest earnings and valuation effects (as in equation 3). We estimate interest earnings as the U.S. interest rate multiplied by lagged level of reserves. This adjusted series is divided by the lag level of reserves and regressed on the U.S. interest rate, as a proxy for valuation effects. The estimated coefficient on the U.S. interest rate is multiplied by the observed U.S. interest rate in each quarter to extract valuation effects from our intervention measure. As a robustness test of this approach, we made the same calculation of adjusted reserves for Brazil and India, and correlated our estimated intervention with actual intervention data. The correlations are 0.71 and 0.62, respectively, for Brazil and India. This suggests that our "adjusted reserve change" proxy for intervention is a reasonable estimate of actual intervention.

[20] However, only the shift in the reserve gap coefficient between the two periods is statistically significant (z-statistic of 3.90, significant at the 1% level).

[21] Other instruments noted on the PBoC website in 2018 were open market operations, reserve requirement ratios, standing lending facility, medium-term lending facility, and pledged supplementary lending facility.

tor and foreign exchange market, we modify the intervention equation in two ways beyond the models estimated for the other three countries investigated. First, we extend the intervention equation by including the broad money supply as an explanatory variable (M2, measured in USD as 100*log(M2) divided by the log lag of nominal GDP)[22]. In addition we treat the current account as an endogenous variable[23]. This methodological adjustment is taken because tight capital controls on the financial account in China could lead to either current account surpluses or FDI inflows automatically increasing international reserves.[24]

Table 7 shows the empirical estimates for China. Panel A shows the Taylor rule estimates and panel B the intervention rule estimates. It is apparent that the central bank in China raises the policy rate in respond to an uptick in inflation, a very robust link that holds across sample periods and model specifications. Policy rates are also linked to the output gap, but with unexpected and significant negative sign, indicating that interest rates are reduced the larger is the output gap. Since GDP is only available for China on an annual basis, this result could be associated with the interpolation methodology. However, when employing industrial production rather than GDP as the output measure[25], the significant

[22] This follows Schroder (2017) who finds both M2 and portfolio equity liabilities as significant determinants of reserve demand. The latter variable is not available past 2011 and not employed in our study. (It from the Lane and Milesi-Ferretti database, updated online through 2011 only).

[23] We instrument the contemporaneous current account in China with three lags of itself.

[24] This is related to the discussion of what constitutes intervention, "passive" increases in reserves that may be caused by interest earnings or valuation effects or "active" purchases and sales in the foreign exchange market. This is further complicated in the Chinese case by extensive capital controls.

[25] GDP data in China is only available at an annual level. Quarterly estimates of GDP are obtained by implementing a cubic spline interpolation. As a result, it is not possible to decompose the approximate quarterly series into the trend and cyclical components that would be needed to calculate the output gap. A

positive coefficient is also obtained, and stands in contrast to estimates from the other EMs in the sample. There is also evidence that large current account surpluses in the pre-GFC period were associated with substantial liquidity in the Chinese financial system, leading the central bank to reduce interest rates. No estimated linkage with the terms-of-trade is statistically significant.

On the external side, we find no evidence that intervention policy systemically responds to (albeit small) variations in the nominal exchange rate or to the broad money supply (M2). However, we find a strong and robust intervention response to deviations in the reserve gap—the central bank systemically reduces its USD purchases when the reserve gap increases. This result holds across sub-samples and model specifications. This robust result is obtained despite the massive buildup of reserves by China, far exceeding "adequate" levels. Moreover, there is evidence that higher current account surpluses also led to more USD purchases prior to the GFC period, as the foreign exchange fund moved to absorb liquidity in the foreign exchange market, but not afterwards[26].

In summary, applying our methodology to Chile, our small EM extension, is in

simple quarter over quarter growth rate is calculated from the interpolated series and used as an alternative measure of the output gap in China. A potential concern with this methodology is that the variation in the interpolated series is being driven by statistical noise rather than actual output fluctuations in China. To alleviate this concern, the baseline Taylor rule in China is re-estimated using both the official annual measure of industrial production, interpolated to a quarterly series, and a quarterly measure of industrial production growth from the OECD. These two alternative measure of the output gap leaves the results qualitatively unchanged. Most noteworthy is that negative and statistically significant coefficients on the output gap are robust to using industrial production. Results omitted for brevity but are available from the authors upon request.

[26] This difference is statistically significant at the 1% level (z-statistic equals 2.65)

line with our previous results. On the other hand, the results for China are at odds with the estimates for the other EMs. Estimation of the output gap in the Taylor rule is particularly problematic due to the lack of reliable quarterly output data in China. Nonetheless, we find a strong and robust inflation response in the Taylor rule and an intervention function consistent with targeting international reserve levels.

1.7 Conclusion

Large emerging markets follow quite different policy configurations in attempting to achieve internal and external balance. India has quite stringent capital controls, and follows a Taylor rule dominated by an output stabilization objective. Inflation has played a much smaller part in influencing interest rates in India, mostly evident in recent years, and the terms-of-trade occasionally plays a role. Brazil, by contrast, has a much more financially open economy and follows an inflation target regime that generally dominates other considerations. Though exchange rate and terms-of-trade fluctuations occasionally influence interest rates in Brazil, we find no evidence that the central bank attempts to stabilize output fluctuations directly.

External policies are more similar in Brazil and India despite differences in capital control regimes. Intervention policies in both countries focus on exchange rate stabilization, i.e. stabilizing the exchange rate with "leaning against the wind" foreign change purchases and sales. In terms of an external financial stability objective, India uses intervention operations to target reserves at a level justified by economic factors. Brazil, on the other hand, started targeting a specific level of reserves only after the Global Financial Crisis

(GFC). Controlling for the exchange rate and the international reserves gap, both countries still made large net quarterly purchases of foreign exchange on average over the sample period.

The impact of the liberalization of international capital controls on policy is complex, depending on market conditions and the specific actions taken to lift restrictions on capital inflows or outflows. We find that greater financial openness affected India and Brazil differently, depending on the particular sequence of administrative measures. This led to varying private capital movements and intervention policy responses. We also find that conflicts in internal and external policy occur occasionally and, for both countries, very large discretionary intervention operations appear negatively linked to discretionary interest rate changes. That is, large unpredicted intervention purchases (sales) accommodate low (high) interest rates, suggesting that external operations are subordinate to domestic policy objectives.

The results for Chile, the extension of our study to a small open economy, suggests the central bank follows a true Taylor rule in balancing output and inflation targets but with more emphasis on inflation prior to the GFC and on output after the GFC. The exchange rate does not appear as a factor either in setting interest rates or intervention operations, and targeting a particular level of reserves only appears after the GFC. China has a more complicated institutional framework for macroeconomic policy than the other three EMs, and quality of output data is also a concern. Nonetheless, we find that Chinese interest rate policy responds strongly to inflation and intervention responds to an international reserves target.

In conclusion, each country has its own idiosyncratic policies, varying over time, but commonalities emerge. Policy interest rates always respond to either inflation or output gaps, frequently both, with varying intensities, and intervention is directed toward managing targeted international reserve levels and usually to exchange rate stabilization. Terms-of-trade and current account fluctuations also occasionally influence intervention operations. In conflicts between interest rate and intervention policies, the former — focused on internal balance — appear to dominate policy.

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1.9 Appendix - Variables description, Tables and Figures

- Δe: Percent change in nominal exchange rate, closing price reported by the Central Bank of Brazil and Reserve Bank of India. Quotations denominated in local currency per unit of US dollar. For quarterly data, exchange rate is for March 31st, June 30th, September 30th, and December 31st (or the closest date available). We applied the log changes and presented as percentage, $\Delta e = 100 \times (\ln(e_t) - \ln(e_t - 1)$.

- $\hat{Y}$: India output measured by Industrial Production. Brazil output is quarterly GDP series reported by the Central Bank of Brazil. Log of output series filtered by Hodrick-Prescott (HP) tecnhique. Output gap is the cyclical component of the HP-filtered log(GDP) series.

- π: Inflation calculated as the anualized log change over local price index. India is the wholesale price index, Brazil is the IPCA (National Index of Consumer Prices, elaborated by the Brazilian Institute of Geography and Statistics). Percent Annualized change, $\pi = 100 \times (\ln(CPI_t) - \ln(CPI_{t-4}))$.

- π^*: India does not publish inflation target. We assume the implicit target constant through the whole period. For Brazil, IT is officially defined by the National Monetary Council and the Central Bank is required by law to pursue it, with some allowed deviations (tolerance bands). The IT changes through time. For 2019, it is defined as 4.25% with a tolerance band of 2% (meaning an accepted interval of [2.25%, 6.25%]).

- $(\pi - \pi^*)$: The inflation gap is measured as the deviation from the target, i.e. $[100 \times (\ln(CPI_t) - \ln(CPI_{t-4})) - \text{inflation target}] = [100 \times (\ln(CPI_t) - \ln(CPI_{t-4})) - \pi^*]$.

- i: Money market rate defined and controlled by the Central Bank of Brazil and Reserve Bank of India, respectively. For Brazil we have used the "SELIC" rate, and for India we've used 3 months money market defined by RBI & India: 1999Q1-2018Q4; Brazil: 2000Q1-2018Q4;

- i^*: The US interest rate is the 3-Month Treasury Bill Rate, published by the

Federal Reserve Economic Data (FRED).

- openness: This variable is from Pasricha et al.(2015). The author provided a detailed dataset for the period 2001-2015 with quarterly frequency. Each data series counts the number of capital flow measures (for example, number of easings of inflow controls or tightenings of outflow controls) undertaken by each country. The variables used from the dataset weighted each policy action by the share of the country's international assets or liabilities that the measure was designed to influence. The policy actions in the dataset were counted by effective dates and included changes for which the announcement and effective dates are different. From the dataset we explored two specific series: "wgt_nettighteningin", and "wgt_neteasingout", that correspond to number of net inflow tightenings, weighted, and number of net outflow easenings, weighted, respectively. As we are insterested to understand the degree of openness of the countries studied, we have transformed the first series "net inflow tightenings" to "net inflow easing" by inverting its sign (a positive tightening means a negative easing and a negative tightening means a positive easing). With the quarterly values of easing inflow and easing outflow we chose to work with the cumulative measures of both easing inflow and outflow combined. As this variable was intended to measure openness, we need to measure the easing policies, regardless of inflow or outflow.

- *R*: Level of Foreign Reserves in USD reported by the Central Bank, includes SDRs and excludes Gold holdings.

- R^*: The Reserve Target values are from IMF "Assessing Reserve Adequacy". The institution's work compares the reserve holdings and alternative metrics of reserve adequacy. This reserves adequacy measure was initially developed in the IMF Board Paper "Assessing Reserve Adequacy" - RAM1 (February 15, 2011), and adjusted in the latest IMF Board Paper "Assessing Reserve Adequacy- Specific Proposals" (December 19, 2014), in order to reflect the outflows during the Global Financial Crisis which were not addressed in RAM1. The IMF Reserve Adequacy estimates adequate volume of reserves for a specific country taking into account exports, imports, broad money, and other liabilities.

- $(R - R^*)$:The Reserve Gap is calculated by the difference of the level of reserves and the adequate level proposed by the IMF (R^*). Log-transformation and percentage presentation is also applied: $100 \times (ln(R) - lnR^*)$

- Appreciation: Dummy variable that assumes value equals to 1 if the local currency appreciates versus US dollar, i.e., $\Delta e < 0$ and value equals 0 otherwise ($\Delta e \geq 0$).

- Spot Intervention: Amount of USD bought and sold in the spot market relative to the level of Reserves.

- Forward Intervention: Amount of USD bought and sold in the forward market relative to the level of Reserves.

- Terms of Trade: Ratio of exports over imports. We have used the following monthly series elaborated by the IMF: Commodity Export Price Index, Individual Commodites Weighted by Ratio of Exports to Total Commodity Exports, Commodity Import Price Index, and Individual Commodites Weighted by Ratio of Imports to Total Commodity Imports. All for the 1999-2018 period.

- Current account: Quarterly data on the net current account balance is obtained from the IMF. The series is normalized by dividing the current account balance by the first lag of nominal GDP and multiplying by 100.

Table 1.1: Descriptive Statistics

Panel A: Entire Sample, 1999Q1 - 2018Q4

	India			Brazil		
Statistic	N	Mean	St. Dev.	N	Mean	St. Dev.
i	84	6.98	1.62	76	13.447	4.579
$\hat{Y}$	84	0.00	2.24	76	−0.207	9.554
π	80	4.56	3.19	76	5.242	3.385
$\pi - \pi^*$	80	4.56	3.19	76	0.419	1.023
Δe	83	0.73	3.04	76	1.019	8.498
$R - R^*$	84	33.12	27.68	76	1.244	49.978
I_{spot}	84	1.56	3.89	76	2.63	6.769
I_{total}	84	0.01	11.64	76	2.581	7.12
openness	60	20.76	15.84	60	1.802	1.193
t.o.t.	76	107.27	11.33	80	95.15	14.37
curr. acc.	83	-1.37	2.01	88	-1.89	2.19

Panel B: Pre Crisis, 1999Q1 - 2008Q4

	India			Brazil		
Statistic	N	Mean	St. Dev.	N	Mean	St. Dev.
i	44	6.93	1.63	36	16.931	3.775
$\hat{Y}$	44	0.25	2.61	36	−0.624	10.049
π	40	4.56	3.19	36	6.268	3.870
$\pi - \pi^*$	40	4.56	3.19	36	0.546	1.254
Δe	43	0.50	2.87	36	−0.148	8.109
$R - R^*$	44	29.68	36.78	36	−42.709	33.72
I_{spot}	44	2.32	4.79	36	4.263	9.358
I_{total}	44	0.14	11.37	36	3.988	9.801
openness	32	8.07	5.67	32	1.409	1.346
t.o.t.	36	106.15	15.36	40	95.58	17.78
curr. acc.	43	-0.78	1.92	47	-1.43	2.61

Panel C: Post Crisis, 2009Q1 - 2018Q4

	India			Brazil		
Statistic	N	Mean	St. Dev.	N	Mean	St. Dev.
i	40	7.04	1.63	40	10.312	2.5
$\hat{Y}$	40	−0.27	1.74	40	0.168	9.198
π	40	3.97	4.05	40	5.057	2.908
$\pi - \pi^*$	40	3.97	4.05	40	0.305	0.755
Δe	40	0.98	3.24	40	2.069	8.801
$R - R^*$	40	36.91	10.51	40	40.802	19.869
I_{spot}	40	0.72	2.34	40	1.161	2.199
I_{total}	40	−0.16	12.08	40	1.315	2.794
openness	28	35.27	10.11	28	2.252	0.798
t.o.t.	40	103.77	2.97	40	97.82	9.34
curr. acc.	40	-2.31	1.61	41	-2.42	1.43

Panel A: Interest Rate Policy	Dependent Variable: i_t			
	India		Brazil	
	(1)	(2)	(1)	(2)
c	1.13^{***}	1.16^{**}	3.51^{***}	5.87^{***}
	(0.39)	(0.56)	(1.31)	(1.38)
$\hat{Y}$	0.11^{***}	0.11^{***}	0.03	0.03
	(0.03)	(0.03)	(0.03)	(0.04)
$\pi - \pi^*$	0.02	0.02	0.60^{***}	0.60^{***}
	(0.02)	(0.02)	(0.22)	(0.16)
Δe	0.03	0.03	0.02	0.03^{*}
	(0.06)	(0.06)	(0.02)	(0.015)
i_{t-1}	0.82^{***}	0.81^{***}	0.65^{***}	0.66^{***}
	(0.05)	(0.05)	(0.11)	(0.04)
t.o.t.		-0.00		-0.013^{**}
		(0.00)		(0.012)
current account		-0.04		0.11
		(0.03)		(0.17)
R^2	0.83	0.82	0.85	0.86
Num. obs.	80	76	79	79

Panel B: Intervention Policy	Dependent Variable: I_t			
	India		Brazil	
	(1)	(2)	(1)	(2)
c	3.23^{***}	3.12	3.12^{*}	25.17^{***}
	(0.71)	(6.21)	(1.70)	(9.36)
Δe	-0.48^{***}	-0.30^{**}	-0.22^{**}	-0.17^{**}
	(0.15)	(0.11)	(0.09)	(0.074)
$R - R^*$	-0.04^{***}	-0.04	-0.04	-0.03
	(0.01)	(0.03)	(0.04)	(0.02)
t.o.t.		0.01		-0.23^{**}
		(0.05)		(0.09)
current account		0.91^{***}		0.18
		(0.24)		(0.39)
R^2	0.13	0.45	0.11	0.32
Num. obs.	83	76	75	75

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 1.2: Baseline Results

Panel A: Interest Rate Policy				Dependent Variable: i_t				
	India				Brazil			
	Pre-Crisis		Post-Crisis		Pre-Crisis		Post-Crisis	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
c	1.48^{***}	0.39	0.86	-6.32^{**}	8.66^{***}	5.13	1.90^{**}	-0.15
	(0.50)	(0.85)	(0.53)	(2.68)	(1.55)	(3, 30)	(0.76)	(1.27)
$\hat{Y}$	0.12^{*}	0.18^{***}	0.16^{***}	0.15^{***}	0.01	0.03	0.02	0.01
	(0.07)	(0.06)	(0.03)	(0.04)	(0.03)	(0.05)	(0.02)	(0.01)
$\pi - \pi^*$	-0.02	0.04	0.04^{**}	0.03^{**}	0.60^{***}	0.61^{***}	0.50^{***}	0.43^{***}
	(0.05)	(0.07)	(0.01)	(0.02)	(0.16)	(0.17)	(0.09)	(0.08)
Δe	-0.02	-0.03	0.08	0.10	0.01	-0.02	0.01	0.01
	(0.03)	(0.02)	(0.08)	(0.09)	(0.03)	(0.03)	(0.01)	(0.01)
i_{t-1}	0.79^{***}	0.57^{***}	0.86^{***}	0.85^{***}	0.41^{***}	0.30^{***}	0.74^{***}	0.72^{***}
	(0.05)	(0.13)	(0.08)	(0.09)	(0.08)	(0.07)	(0.07)	(0.10)
t.o.t.		0.02^{*}		0.07^{**}		0.06		0.02
		(0.01)		(0.03)		(0.04)		(0.02)
cur. acc.		-0.07^{**}		-0.07		0.13		-0.15
		(0.03)		(0.06)		(0.22)		(0.10)
R^2	0.85	0.84	0.86	0.87	0.78	0.80	0.93	0.94
Num. obs.	40	36	40	40	39	39	40	40

Panel B: Intervention Policy				Dependent Variable: I_t				
	India				Brazil			
	Pre-Crisis		Post-Crisis		Pre-Crisis		Post-Crisis	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
c	3.57^{***}	-23.78^{*}	4.63^{**}	7.92	3.64^{*}	46.71^{***}	5.06^{***}	3.65^{**}
	(1.15)	(13.46)	(1.82)	(8.26)	(2.05)	(8.65)	(1.08)	(1.42)
Δe	-0.66^{**}	-0.37^{**}	-0.35^{**}	-0.35^{**}	-0.37^{***}	-0.11	0.04^{**}	0.02
	(0.30)	(0.14)	(0.15)	(0.15)	(0.10)	(0.14)	(0.02)	(0.02)
$R - R^*$	-0.03^{*}	0.07	-0.10^{**}	-0.10^{***}	-0.03	-0.13^{***}	-0.09^{***}	-0.09^{***}
	(0.02)	(0.06)	(0.04)	(0.03)	(0.04)	(0.03)	(0.02)	(0.01)
t.o.t.		0.21^{**}		-0.02		-0.53^{***}		0.00
		(0.10)		(0.08)		(0.10)		(0.01)
cur. acc.		1.13^{***}		0.51^{**}		-0.25		-0.38^{**}
		(0.30)		(0.24)		(0.39)		(0.18)
R^2	0.15	0.63	0.14	0.26	0.11	0.37	0.29	0.36
Num. obs.	43	36	40	40	35	35	40	40

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Pre-Crisis corresponds to periods before 2009Q1

Table 1.3: Pre and Post Global Financial Crisis

Panel A: Interest Rate Policy - Pre GFC

	Dependent Variable: i_t			
	India		Brazil	
	(1)	(2)	(1)	(2)
c	1.987***	3.2289***	6.4176*	8.8692**
	(0.3249)	(0.8176)	(3.4913)	(4.1772)
$\hat{Y}$	0.1277**	0.2475***	−0.0176	0.0041
	(0.0691)	(0.0578)	(0.0390)	(0.0416)
$\pi - \pi^*$	−0.0276	.0909	0.5248	0.5183
	(0.0489)	(.0849)	(0.3105)	(0.3798)
Δe	0.0323	0.0590	0.0089	0.0006
	(0.0336)	(0.0373)	(0.0294)	(0.0279)
i_{t-1}	0.5994***	0.4054***	0.5103*	0.4080
	(0.0455)	(0.1175)	(0.2598)	(0.3249)
i_{US}	0.2474***	0.236***	0.1872	0.2717
	(0.0511)	(0.0473)	(0.2306)	(0.3268)
openness		−0.0809***		−0.6089*
		(0.0284)		(0.3550)
R^2	0.8908	0.8766	0.8198	0.8369
Num. obs.	40	32	32	32

Panel B: Spot Intervention

	Dependent Variable: I_t			
	India		Brazil	
	Pre-Crisis	Post-Crisis	Pre-Crisis	Post-Crisis
c	4.78***	−2.09	−9.39***	8.06***
	(1.35)	(4.51)	(2.14)	(1.77)
Δe	−0.26**	−0.27*	−0.27	−0.00
	(0.11)	(0.16)	(0.20)	(0.02)
$R - R^*$	0.12	−0.02	−0.14***	−0.08***
	(0.10)	(0.05)	(0.03)	(0.02)
openness	−0.97**	0.11	6.17***	−1.50***
	(0.42)	(0.09)	(0.81)	(0.51)
R^2	0.66	0.30	0.49	0.41
Num. obs.	32	28	32	28

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Pre-Crisis corresponds to periods before 2009Q1

Table 1.4: Capital Account Liberalization (Openness)

Dependent Variable ϵ_{taylor}	India	Brazil
c	0.14	0.87^{***}
	(0.12)	(0.10)
$\epsilon_{intervention} \lvert (\lvert \epsilon_{intervention} \rvert) > p90$	-0.21^{*}	-0.09^{*}
	(0.11)	(0.04)
R^2	0.17	0.05
Num. obs.	16	16

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 1.5: Residual Analysis

Panel A: Interest Rate Policy	Dependent Variable: i_t					
	Full Sample		Pre-Crisis		Post-Crisis	
	(1)	(2)	(3)	(4)	(5)	(6)
c	0.76***	1.60***	0.40	−2.98***	1.79***	2.11
	(0.25)	(0.54)	(0.35)	(0.95)	(0.52)	(1.43)
$\hat{Y}$	0.07***	0.10***	0.02	−0.03	0.21***	0.18**
	(0.03)	(0.02)	(0.03)	(0.04)	(0.06)	(0.07)
$\pi - \pi^*$	0.20***	0.18***	0.22***	0.28***	0.05	0.07
	(0.06)	(0.05)	(0.04)	(0.05)	(0.12)	(0.11)
Δe	0.02	0.01	0.01	0.01	0.00	−0.01
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
i_{t-1}	0.64***	0.58***	0.74***	0.65***	0.44***	0.40***
	(0.08)	(0.09)	(0.08)	(0.09)	(0.05)	(0.04)
$t.o.t.$		−0.01		0.04***		−0.00
		(0.00)		(0.01)		(0.01)
current account		−0.07		−0.11**		−0.06
		(0.04)		(0.05)		(0.05)
R^2	0.81	0.82	0.84	0.88	0.84	0.85
Num. obs.	80	76	40	36	40	40

Panel B: Intervention Policy	Dependent Variable: I_t					
	Full Sample		Pre-Crisis		Post-Crisis	
	(1)	(2)	(3)	(4)	(5)	(6)
c	1.63**	2.80	1.41**	3.67	13.62***	19.08***
	(0.64)	(3.83)	(0.60)	(8.25)	(4.94)	(5.62)
Δe	0.08	0.07	0.08	0.04	0.26	0.24
	(0.08)	(0.08)	(0.11)	(0.06)	(0.19)	(0.18)
$R - R^*$	−0.00	−0.00	0.01	0.02	−0.14***	−0.23***
	(0.01)	(0.01)	(0.03)	(0.03)	(0.05)	(0.05)
$t.o.t.$		−0.01		−0.02		0.01
		(0.04)		(0.08)		(0.03)
current account		−0.04		−0.14		−0.80**
		(0.17)		(0.25)		(0.37)
R^2	0.00	0.01	0.03	0.05	0.05	0.05
Num. obs.	75	75	35	35	40	40

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Pre-Crisis corresponds to periods before 2009Q1

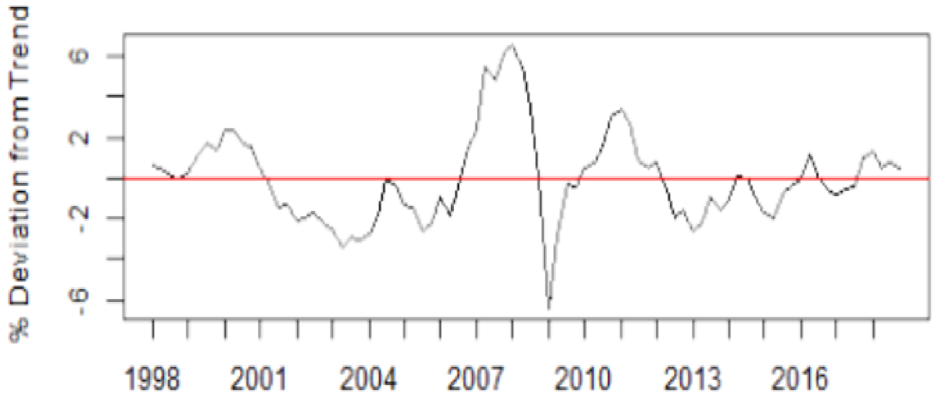
Table 1.6: Chile Policy Rules

Panel A: Interest Rate Policy		Dependent Variable: i_t				
	Full Sample		Pre-Crisis		Post-Crisis	
	(1)	(2)	(3)	(4)	(5)	(6)
c	2.17***	1.77*	1.57***	2.13***	2.86***	4.81
	(0.66)	(0.90)	(0.33)	(0.41)	(0.92)	(3.20)
Y	−0.39**	−0.41*	−0.28*	−0.39***	−0.76**	−0.86**
	(0.18)	(0.24)	(0.15)	(0.07)	(0.35)	(0.40)
$\pi - \pi^*$	0.10***	0.16***	0.04*	0.12***	0.22***	0.17**
	(0.04)	(0.04)	(0.02)	(0.03)	(0.06)	(0.07)
Δe	0.00	−0.02	0.01	0.01	−0.07	−0.05
	(0.02)	(0.03)	(0.03)	(0.02)	(0.05)	(0.05)
i_{t-1}	0.28**	0.17	0.52***	0.36***	0.08	0.05
	(0.13)	(0.12)	(0.13)	(0.08)	(0.12)	(0.15)
$t.o.t.$		0.01		0.00		−0.01
		(0.01)		(0.00)		(0.02)
current account		−0.07***		−0.07***		−0.04
		(0.02)		(0.01)		(0.12)
R^2	0.31	0.37	0.33	0.47	0.35	0.36
Num. obs.	65	64	37	36	28	28

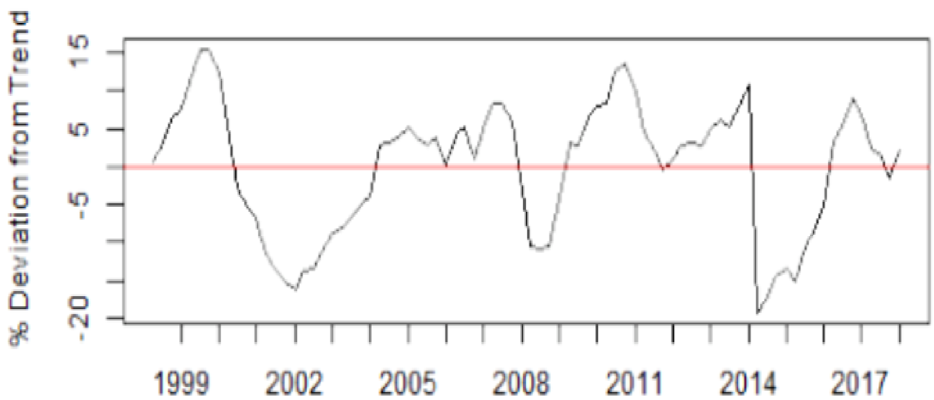
Panel B: Intervention Policy		Dependent Variable: I_t				
	Full Sample		Pre-Crisis		Post-Crisis	
	(1)	(2)	(3)	(4)	(5)	(6)
c	26.25***	37.79***	29.23***	−33.44	33.07***	66.64**
	(2.65)	(12.85)	(5.87)	(39.84)	(5.99)	(24.54)
Δe	−0.17	−0.19	−0.15	−0.08	−0.21	−0.24
	(0.10)	(0.17)	(0.14)	(0.24)	(0.14)	(0.26)
$R - R^*$	−0.06***	−0.06***	−0.07***	−0.08	−0.07***	−0.11*
	(0.01)	(0.01)	(0.02)	(0.05)	(0.01)	(0.06)
$t.o.t.$		−0.03		0.25		0.03
		(0.04)		(0.15)		(0.05)
current account		−0.28		1.32*		−1.69
		(0.34)		(0.69)		(1.39)
$M2$		−0.02		0.15		−0.08
		(0.08)		(0.10)		(0.07)
R^2	0.63	0.62	0.27	0.51	0.40	0.33
Num. obs.	59	59	19	19	40	40

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Pre-Crisis corresponds to periods before 2009Q1

Table 1.7: China Policy Rules

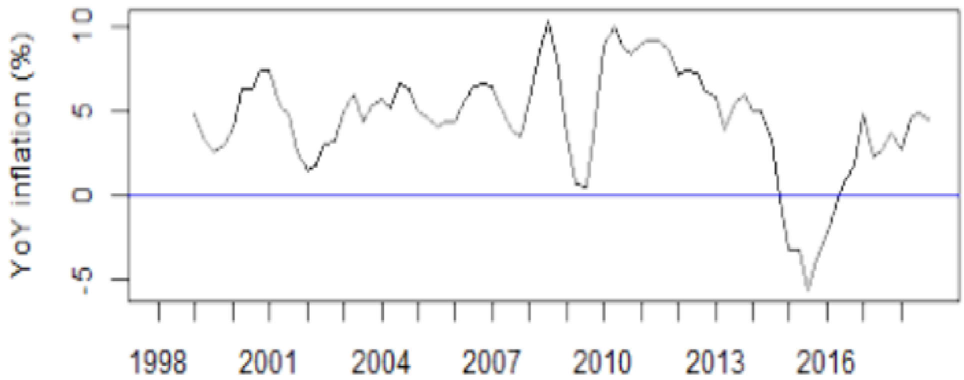


Panel A: India

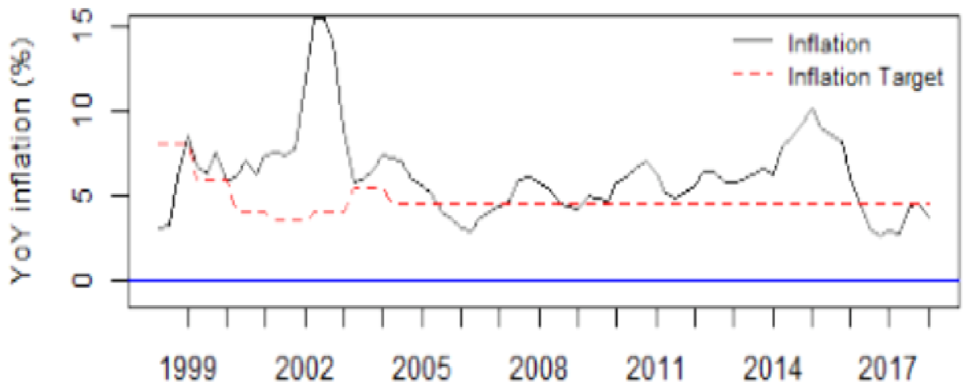


Panel B: Brazil

Figure 1.1: Output Gap



Panel A: India



Panel B: Brazil

Figure 1.2: Inflation

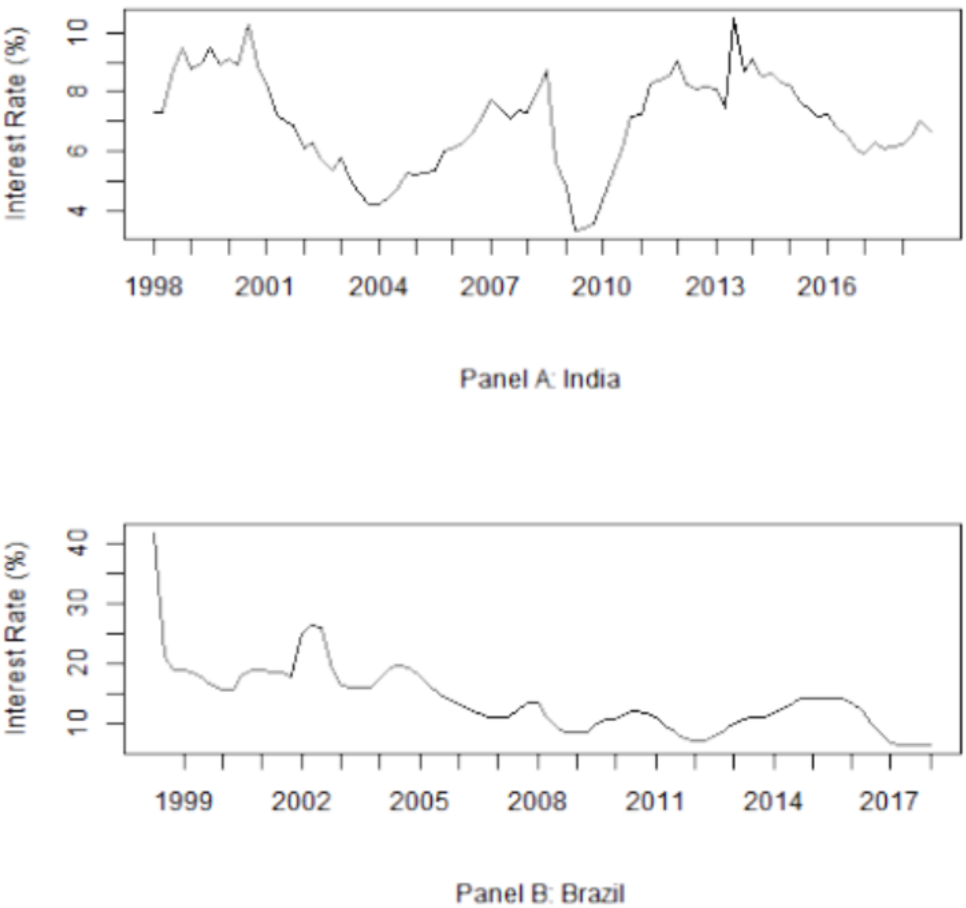


Figure 1.3: Money Market Interest Rates

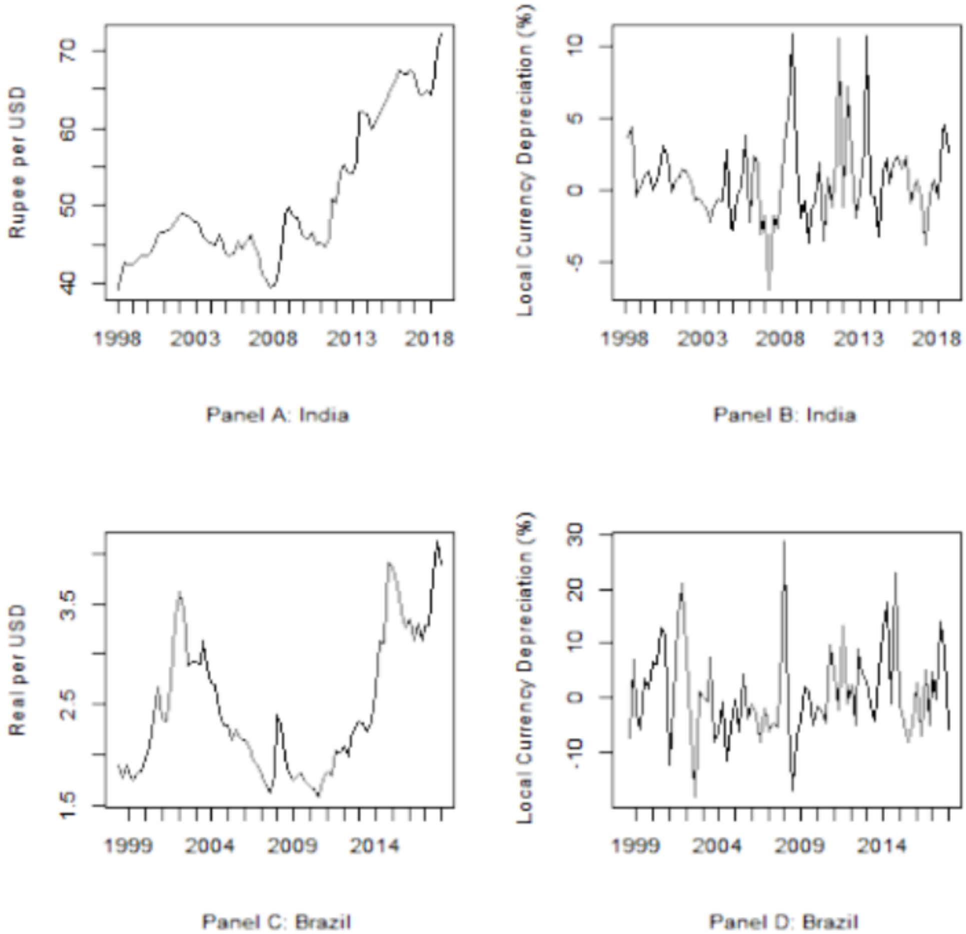


Figure 1.4: Exchange Rates

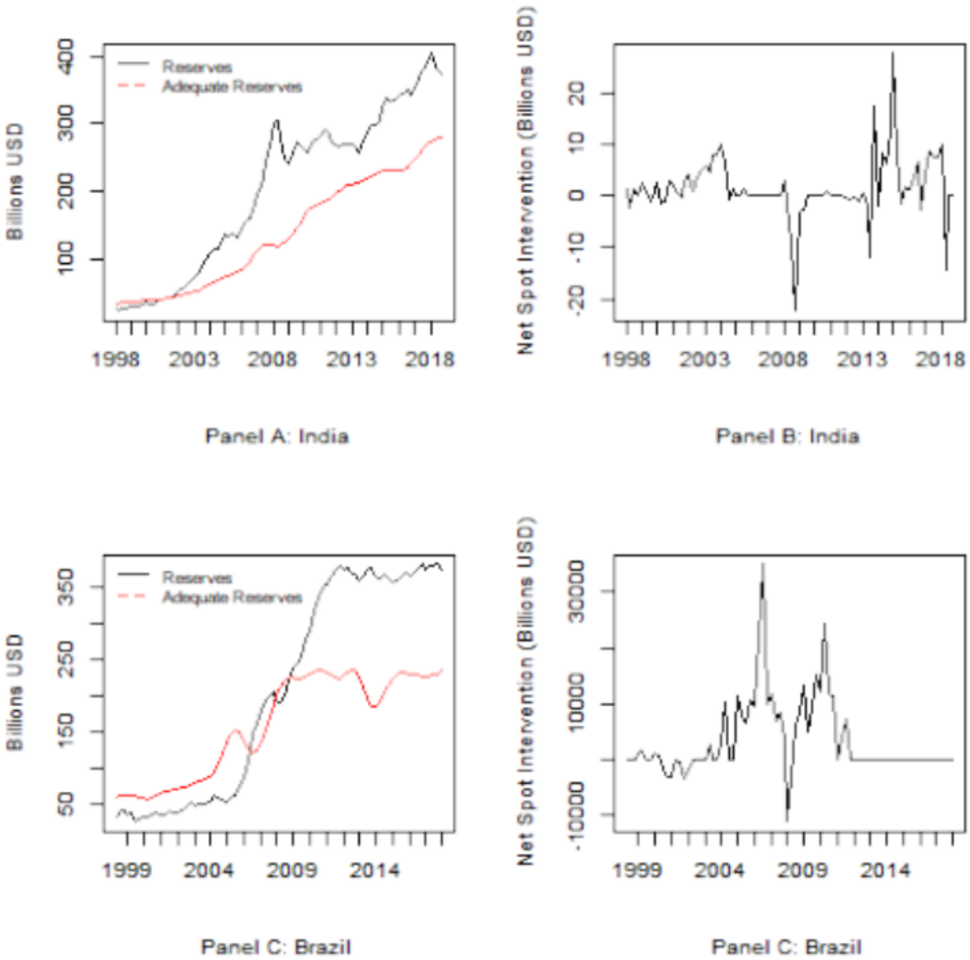


Figure 1.5: Reserves, Reserve Adequacy and Foreign Exchange Market Intervention

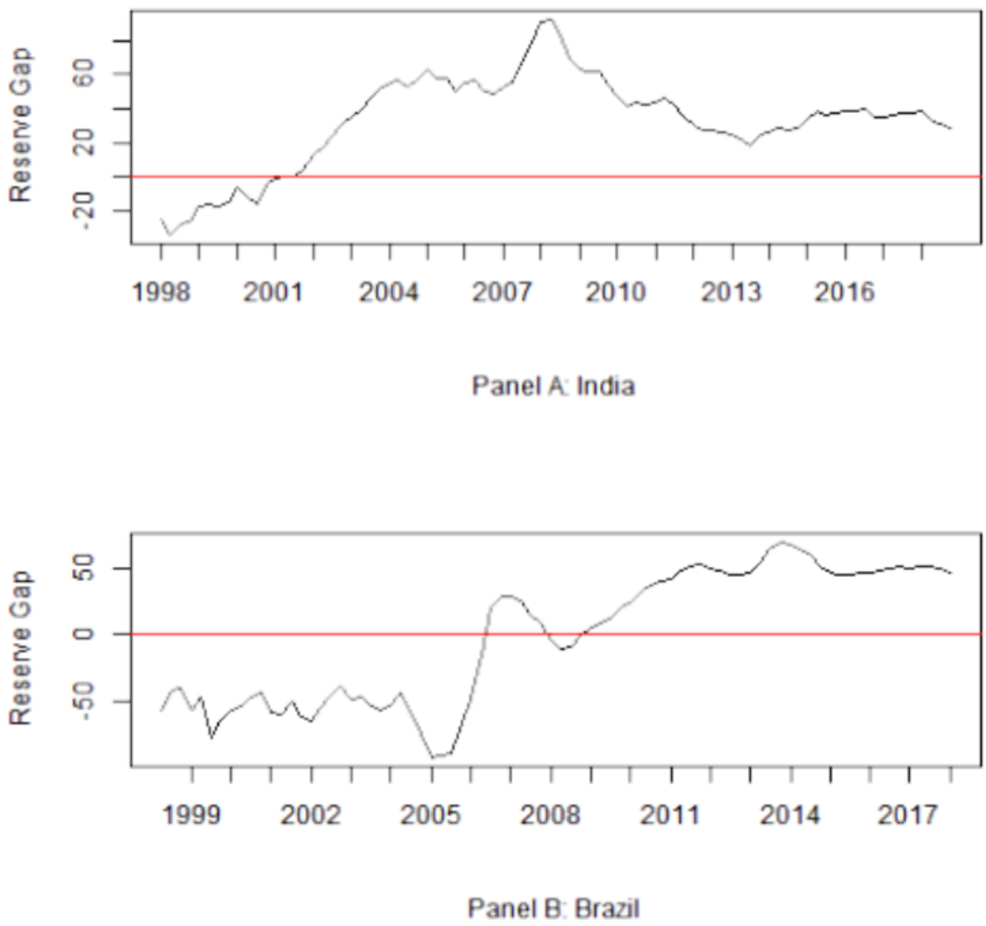


Figure 1.6: Reserve Gap

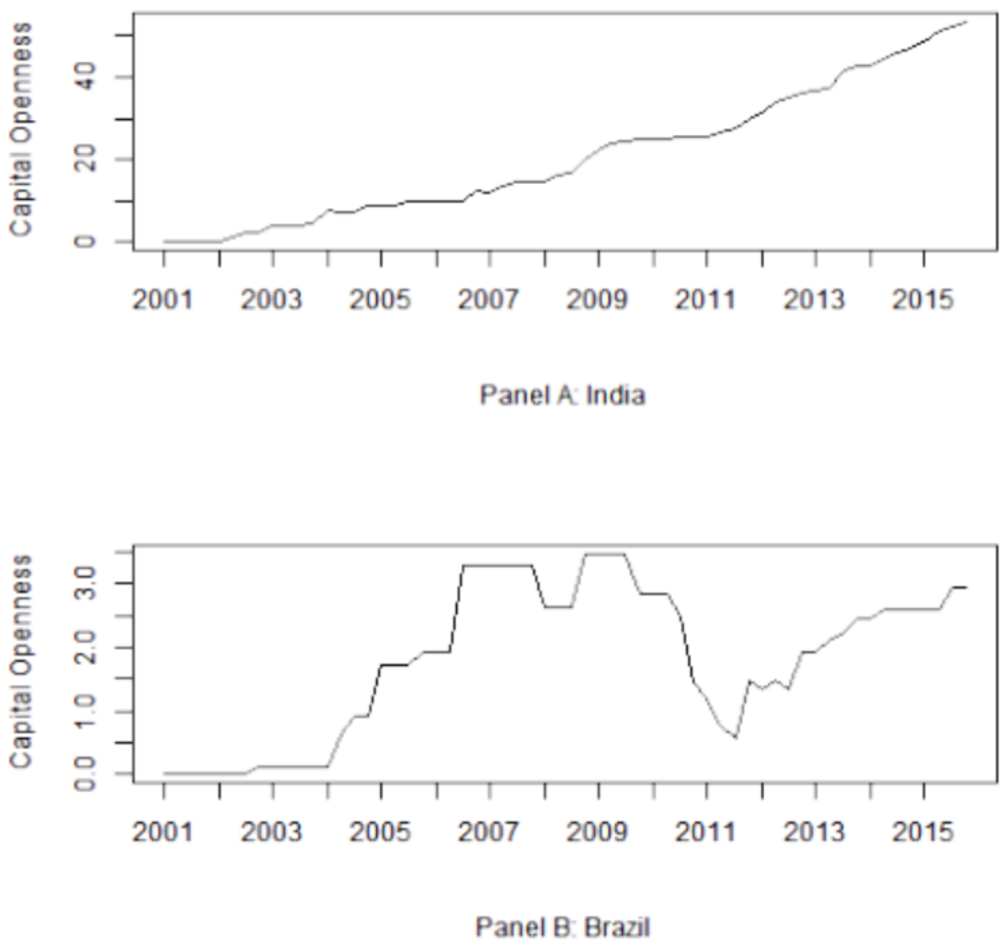


Figure 1.7: Capital Openness

Chapter 2

Regional Trade Agreements and A Gravity Model of Consumption Risk Sharing

2.1 Introduction

Classic economic theories identify frictions in the goods market as an explanation for the lack of consumption risk sharing among countries. For instance, Obstfeld and Rogoff (2001) argue that trade costs make it costly for countries to share risk through the exchange of goods and can therefore account for the low cross-country consumption correlations observed in the data.

We test the theory empirically by exploiting the variation in trade costs amongst country pairs. We find that regional trade agreements (RTA hereafter) facilitate bilateral risk sharing between trade partners for a panel of 178 countries over the 1970-2014 period. This finding based on policy shifts supports the viewpoint that reducing trade costs promotes consumption risk sharing. In addition, we provide cross-sectional evidence by establishing a gravity model of consumption risk sharing. As trade costs increase in geographical distance, we hypothesize and then confirm that bilateral risk sharing is weaker for countries which are more distant from each other. Lastly, we find that geographical distance becomes less relevant for consumption risk sharing once countries are RTA members. All the evidence points towards the importance of trade costs for explaining imperfect cross-country consumption risk sharing.

Following the literature, including Sorensen and Yosha (1998) and Kose et al. (2009), we measure a country's consumption risk sharing as the response of its relative consumption growth to its relative output growth. A greater response suggests a lower degree of consumption risk sharing. Consider the extreme case where two countries that face output risk cannot trade assets or ship goods across borders, each country's consumption is equal to its own output. There is no risk sharing between the two countries since the difference in their consumption growth equals that in output growth. In contrast, when risk sharing is perfect the level of a country's consumption does not fluctuate with its own current output but that of the aggregate economy. As a result, the output difference between countries does not influence their relative consumption to each other's.

In this paper we focus on bilateral risk sharing which has received little attention in the literature. In a classical model with complete markets, competitive equilibrium coincides with the allocation of a social planner who makes centralized decisions regardless of bilateral economic exchanges. Nevertheless, in the real world there exist frictions of different magnitudes across country pairs that segment complete markets and make bilateral risk-sharing relationship important for analyzing consumption patterns.

To examine the influence of trade costs on consumption risk sharing, we exploit both cross-sectional and time-series variations in trade costs across country pairs. As discussed earlier, our empirical analysis consists of three parts. To start with, we examine whether RTAs promote bilateral risk sharing. An RTA is a treaty between two or more countries that aims to foster trade partnership. By regulating tariffs and other forms of trade barriers, RTAs reduce the trade costs among member countries. Therefore, we examine consumption patterns around RTA events to uncover the relationship between trade costs and risk sharing. We conduct this analysis for a panel of 178 countries who constitute 31684 country pairs over the 1970-2014 period. We interact a dummy variable that equals 1 when a pair of countries both participate in an RTA and 0 otherwise with the two countries' difference in output growth. With the difference in their consumption growth as the dependent variable, the coefficient of the interaction term reveals the influence of RTAs on bilateral risk sharing. After controlling for time fixed effects, we find that participating in an RTA lowers the response of relative consumption to output growth by about 0.11 (equivalent to 0.9 standard deviations). The result is robust when we employ both pooled regressions and panel analysis with country-pair fixed effect models.

In addition to exploiting policy changes, we provide cross-sectional evidence that demonstrates the impact of trade costs on consumption risk sharing. Geographical distance is acknowledged to be a vital determinant for trade costs. The more distant countries are from one another, the higher trade costs it incurs to ship goods between them. If consumption risk sharing is hampered by trade costs, we should expect that country pairs with greater geographical distance in between exhibit weaker risk sharing. We conduct a two-step analysis to test this hypothesis. In the first step we calculate the bilateral risk-sharing coefficients using the real GDP and consumption data of the 178 countries over the 1970-2014 period in our sample. In the second step we confirm that the risk-sharing coefficients are negatively correlated with geographic distance and positively correlated with the product of GDPs for country pairs. We call this finding a gravity model of consumption risk sharing. The gravity model has emerged as a workhorse in the literature due to its empirical success in predicting bilateral trade flows. More recently, it has been applied in a range of areas to document the importance of geographical variables for explaining economic linkages across countries.[1] This paper contributes to this stand of literature by establishing a gravity model of consumption risk sharing. Based on the regression results, a 1% increase in geographic distance lowers the response of relative consumption to output growth for a country pair by 0.11 (or 0.36 standard deviations). The result remains robust when controlling for other common gravity variables including GDP per capita, population, common language, and common legal system.

Last but not least, we bring the previous analyses together to build the causal link between trade ties and the gravity model. Trade may not be the only channel through which geographic distance influences risk sharing. Specifically, countries can share risks

[1] For instance, Portes and Rey (2005) show that a gravity model explains international transactions in financial assets. Ramos and Surinach (2017) use a gravity model to analyze bilateral migration in Europe. Lustig and Richmond (2019) study the gravity effect in the factor structure of exchange rates.

through financial exchanges and labor mobility. Since the literature has acknowledged the importance of geographic distance for migration and financial flows, additional evidence is needed to attribute the gravity model of risk sharing to the trade channel. To this end, we incorporate RTAs and geographic distance in a single regression. If the trade channel contributes to risk sharing across countries, we should expect that geographic distance becomes less relevant for risk sharing in the presence of RTAs. We confirm the hypothesis in the data by documenting a negative correlation between relative consumption growth and an interaction term of the RTA dummy, distance and output growth. As a result, we conclude that trade costs can at least partially explain why risk sharing deteriorates as the geographical distance between countries increases. This finding echoes the main argument of the paper that trade costs impede consumption risk sharing across countries. Therefore, lifting trade barriers will yield welfare gains by strengthening countries' ability to share risks and smooth consumption.

This paper speaks to a substantial body of literature in international economics. First and foremost, imperfect consumption risk sharing remains to be one of the major puzzles in international macroeconomics (Obstfeld and Rogoff (2001)). On the theoretical front, papers including Obstfeld and Rogoff (2001), Dumas and Uppal (2001), and Backus and Smith (1993) study the role of trade costs in the goods market when explaining the lack of international risk sharing. Our paper provides empirical evidence for their theories directly by exploiting cross-sectional as well as time-series variations in trade costs amongst country pairs. Besides trade costs, financial frictions that prohibit countries from trading state-contingent assets have been acknowledged to impede cross-country risk sharing (e.g.

Lewis (1996) and Kollmann (1995)). In an empirical paper that also exploits institutional changes like ours, Kose et al. (2009) examine whether financial liberalizations facilitate risk sharing and find little evidence. In our paper we control for country-pairs' financial liberalization status when studying RTA events that do not coincide with financial integration in order to isolate the effects of the trade channel on risk sharing.

Furthermore, this paper is related to several influential studies that investigate the patterns and consequences of cross-country risk sharing. For instance, Kalemli-Ozcan et al. (2003) find that countries or regions with better risk sharing exhibit higher industrial specialization. We follow their two-step approach in our paper when constructing the measure of risk sharing first and then exploring its correlation with variables of interest. In Section 3.2 we establish the gravity model by finding that risk sharing increases with country-pairs' GDP but decreases with geographic distance. Moreover, Fitzgerald (2012) builds a structural model to disentangle the effects of financial frictions and trade costs on the lack of consumption risk sharing. Our paper focuses on providing empirical evidence in the trade channel. In addition, Callen et al. (2015) evaluate the degree of risk sharing that can be achieved by small sets of countries given that pooling worldwide risk is costly. In a similar spirit, we examine pairwise risk sharing acknowledging the difficulty of sharing risks among all the countries in the world.

This paper also contributes to the extensive empirical literature on the gravity model. Since being introduced by Isard (1954) and Tinbergen (1962), the model has merged as a classic framework in the trade literature due to its success in matching bilateral trade flows. More recently, seminal works including Anderson and van Wincoop

(2003) and Eaton and Kortum (2002) refine the theoretical foundations of the framework that rationalize empirical regularities of bilateral trade. In addition to trade, the gravity model has recently been applied to a wide range of topics including financial assets (e.g. Portes and Rey (2005), Martin and Rey (2004), and Okawa and van Wincoop (2012) and labor migration (e.g. Lewer and Van den Berg (2008) and Ramos and Surinach (2017). Our paper contributes to this literature by exploring the role of geographic distance in shaping consumption allocations.

The remainder of the paper proceeds as follows: Section 2 describes the data and methods of constructing risk-sharing coefficients. Section 3 presents empirical results as to how trade costs influence consumption risk sharing. Section 4 concludes.

2.2 Data

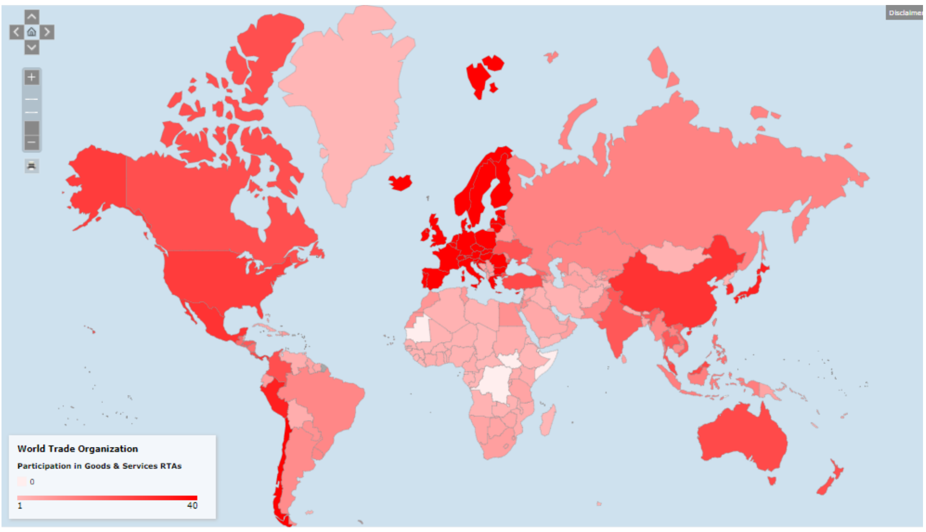
To examine the influence of trade ties on consumption risk sharing we combine data on regional trade agreements, GDP, consumption, and geographical distance among countries. In this section we describe how we collect and analyze the data.

2.2.1 Regional Trade Agreements

We obtain the information on regional trade agreements from the World Trade Organization (WTO) and the Centre d'Études Prospectives et d'Informations Internationales (CEPII). The dummy for regional trade agreements (RTA) is 1 for the period where a pair of countries both participate in a specific RTA. The WTO classifies RTAs into four groups: customs unions, economic integration agreements, free trade agreements, and partial scope agreements. We do not consider the last group as RTAs in our analysis since they only cover specific goods and services. Meanwhile we exclude the events where economic integration agreements coincide with policies that promote financial integration to isolate the effect of trade ties on consumption risk sharing.

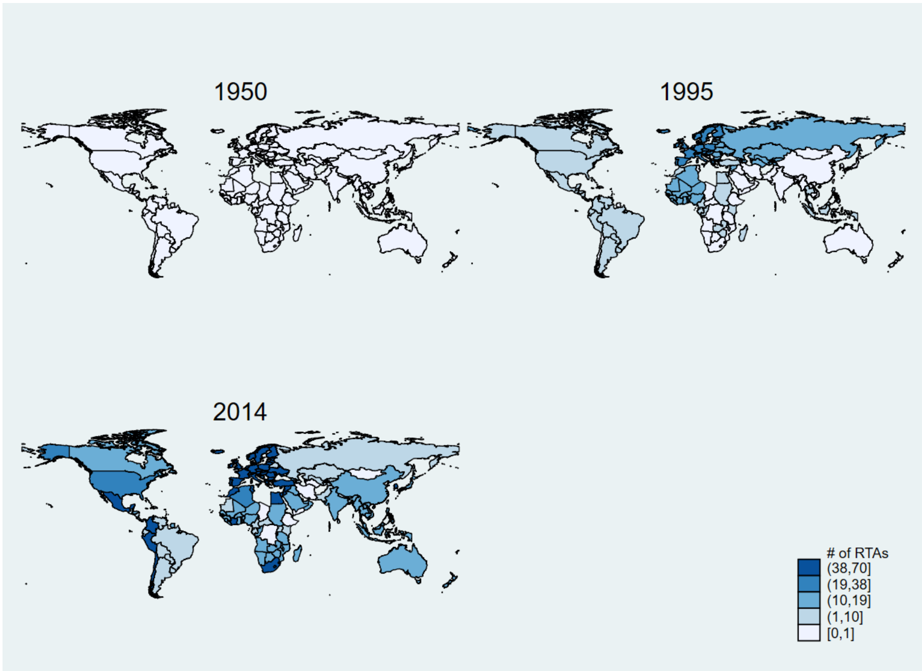
Figure 2.1 displays the global map of RTAs as of July 2019. There are close to 300 RTAs signed bilaterally or multilaterally by groups of countries. Figure 2.2 tracks the historical occurrence of RTAs. It illustrates that the coverage of RTAs has been remarkably expanded over the decades. Table 2.6.1 provides the list of countries in our sample. For the countries that have ever joined in any RTA from 1950 to 2014, we also list the number of RTAs they have been a member of, number of countries that have ever been their partners in any RTA, and the average duration (in years) of RTAs they have participated in.

Figure 2.1: Current RTAs



Source: WTO

Figure 2.2: Historical RTAs



Source: WTO and CEPII

2.2.2 GDP, consumption, and risk sharing

We collect the real GDP, real consumption, and population data from the Penn World Table (PWT) version 9.0. Our sample covers 178 countries over the 1970-2014 period.

Following the literature including Sorensen and Yosha (1998) and Kose et al. (2009), we measure a country's consumption risk sharing as the response of its relative consumption growth to its relative output growth. Specifically, we are interested in bilateral risk sharing so that we can exploit pair-specific factors including RTAs and geographic distance in order to provide a more robust understanding of the factors that shape risk-sharing patterns. We evaluate risk sharing between country i and j from

$$\Delta log\ c_{it} - \Delta log\ c_{jt} = \alpha_{ij} + \beta_{ijt}(\Delta log\ y_{it} - \Delta log\ y_{jt}) + \epsilon_{ijt}, \tag{2.1}$$

where $\Delta log\ c_{it}$ ($\Delta log\ c_{jt}$) denotes the growth of log real per-capita consumption of country $i(j)$ at time t, and $\Delta log\ y_{it}$ ($\Delta log\ y_{jt}$) denotes the growth of log real per-capita output.

A higher coefficient β_{ijt} suggests a lower degree of consumption risk sharing. In the case with perfect risk sharing, relative consumption growth should not vary with relative output growth, which yields a coefficient of 0. In the opposite case where there is no risk sharing, a country's consumption is solely determined by its own output. In this scenario relative consumption growth should equal relative output growth across countries such that $\beta_{ijt} = 1$. Therefore, the better a country is able to share its risks with another, the smaller will be the influence of its relative output on consumption (measured by a lower value for β_{ijt}). For simplicity, we define the bilateral risk-sharing coefficient as $RS_{ijt} \equiv 1 - \beta_{ijt}$. A higher RS_{ijt} stands for better risk sharing.

Table 2.1 shows the summary statistics of RS_{ijt} estimated with the annual data from 1970 to 2014 for all the country pairs in our sample. Each cell reports the mean value and the standard error is in parenthesis. Column (1) reports the coefficients for the years when two countries are RTA partners, column (2) reports the coefficients for the years when they are not bound by any RTA, and column (3) reports the difference between the two coefficients. All the estimates across the three columns are significantly different from zero at the 1% level. From the table when country-pairs are regional trade partners, the mean value of risk-sharing coefficients is 0.572, which is much higher than the value 0.416 when countries are not partners under RTAs. If we split countries into different groups, we find the RTAs benefit risk-sharing between industrial and developing countries to a greater extent compared to risk-sharing between countries in the same income group. Across all types of country pairs, there is a robust pattern that risk sharing improves under RTAs.

To exemplify the pattern, we estimate the risk-sharing coefficients RS_{ijt} over six-year rolling windows and show them graphically for a group of European countries. As is illustrated in Figure 2.3, bilateral risk sharing remarkably improves after the Single Market was established in the mid 1990's. [2]

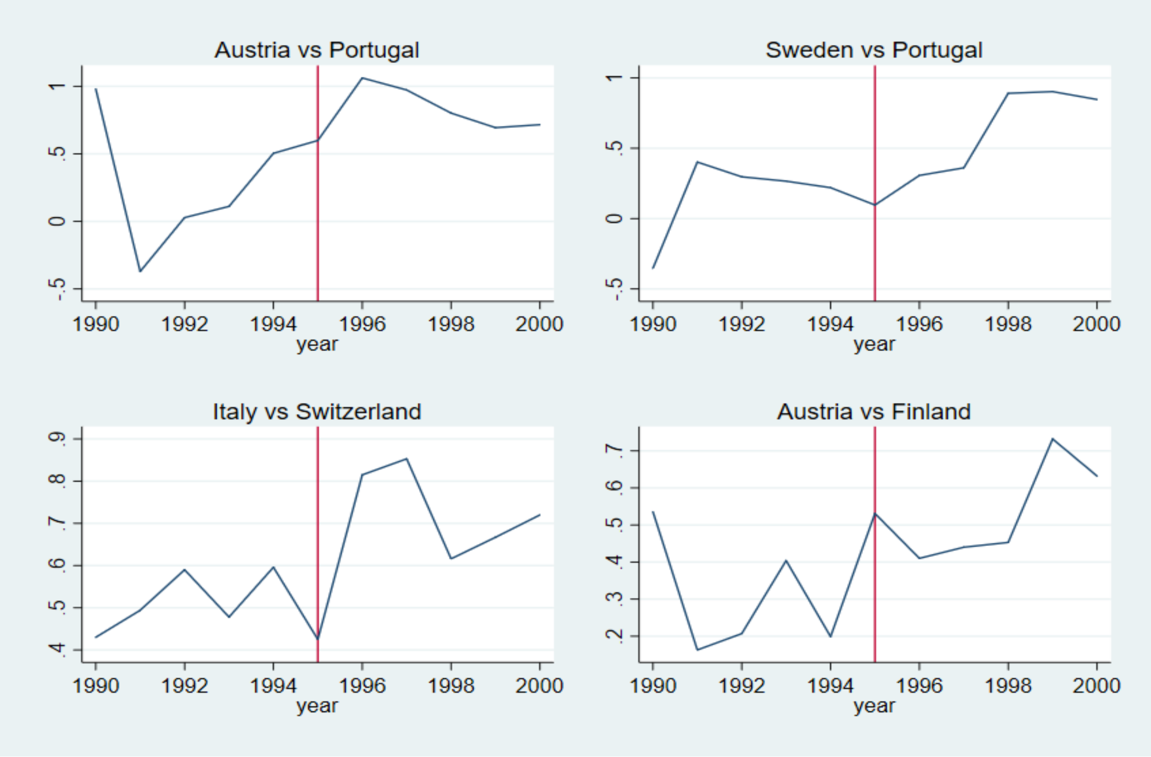
[2] Austria, Sweden, and Finland became the new member states of the treaty in 1995. The Switzerland was not an official member, but it signed a separate treaty with the members under EFTA.

Table 2.1: Summary Statistics of Risk-sharing Coefficients

	(1) w/ RTA	(2) w/o RTA	(3) Difference
All types of countries	0.572 (0.009)	0.416 (0.009)	0.156 (0.012)
Industrial and industrial	0.426 (0.009)	0.344 (0.024)	0.082 (0.024)
Industrial and developing	0.708 (0.025)	0.400 (0.012)	0.308 (0.027)
Developing and developing	0.477 (0.012)	0.434 (0.018)	0.043 (0.020)

This table reports bilateral risk sharing coefficients $RS_{ijt} \equiv 1 - \beta_{ijt}$, where β_{ijt} is estimated from equation 2.1. Column (1) reports the coefficients for the years when two countries are RTA partners, and column (2) reports the coefficients for the years when they are not bound by an RTA. Each cell reports the average value in the relevant subsample and the standard error is in parenthesis. The designation of "industrial" and "developing" countries is based on the Statistics Division of the United Nations.

Figure 2.3: Bilateral Risk Sharing before and after RTAs



Evolution of risk sharing measured as $RS_{ijt} = 1 - \beta_{ijt}$ for selected pairs of countries. Vertical lines indicate the implementation dates of regional trade agreements.

2.2.3 Geographic Distance

We add spatial features to our analysis by examining how geographic distances influence bilateral risk sharing. The benchmark measure of geographic distance between two countries comes from the CEPII, which calculates population-weighted distance between the biggest cities of those two countries. For robustness, we also consider simple distance calculated with the geographical coordinates (latitudes and longitudes) of the capital cities.

2.3 Empirical Analysis

In this section we employ econometric analysis to examine the influence of trade ties on risk sharing. First we test whether regional trade agreements promote bilateral risk sharing. Second we empirically establish a gravity model of risk sharing. Last we combine the two pieces and find that geographical distance is less of an obstacle for risk sharing in the presence of RTAs.

2.3.1 Cross-country Risk Sharing and RTAs

In this section we study consumption patterns around RTA events to provide evidence for the influence of trade costs on consumption risk sharing. We take two approaches to evaluate the impact of RTAs: pooled panel regressions and fixed effects models. The former approach allows us to exploit both cross-sectional and time-series variations in country pairs' exposure to RTAs. The second approach focuses on within-country-pair variations over time.

We use annual data for a panel of 178 countries who constitute 31684 country pairs over the 1970-2014 period. Our pooled panel regression has the following specification

$$\begin{aligned} \Delta log\ c_{it} - \Delta log\ c_{jt} &= \alpha + \beta_1(\Delta log\ y_{it} - \Delta log\ y_{jt}) + \beta_2 RTA_{ijt} \\ &\quad + \beta_3 RTA_{ijt} \times (\Delta log\ y_{it} - \Delta log\ y_{jt}) + \eta_t + \eta_i + \eta_j + \epsilon_{ijt}, \end{aligned} \tag{2.2}$$

where $\Delta c_{it}(c_{jt})$ denotes the change in real consumption per capita of country $i(j)$ at time t and $\Delta y_{it}(y_{jt})$ denotes that of the real output per capita. As discussed earlier, the response of the relative consumption growth to the relative output growth measures the two countries' ability to share risks. Moreover, RTA_{ijt} is a dummy variable that equals 1 for the periods where the country pair participates in a regional trade agreement and 0 otherwise. A negative β_3 suggests that bilateral risk sharing improves in the presence of RTAs. η_t represents time fixed effects, which captures the world aggregate output shock at time t. η_i, η_j represent country fixed effects that capture time-invariant country-specific characteristics. The standard errors ϵ_{ijt} are clustered at country pairs to control for potential heteroskedasticity and autocorrelation. In addition to the baseline specification, we consider other variables that could potentially influence bilateral consumption risk sharing as controls, including the product of the two countries' population and GDP per capita in logs at time t, as well as the two countries' product of GDP volatility over the sample period.

Table 2.2 reports the estimation results. Panel A presents the results for the full sample of country pairs formed by 178 countries. The coefficient estimate for the relative output growth is around 0.3 in all the regressions. The fact that it is between 0 and 1 in value suggests imperfect risk sharing. More importantly, the coefficient of the interaction term with RTA and relative output growth is significantly negative, which implies that participating a regional trade agreement facilitates a country pair's bilateral risk sharing. Based on the estimates, being RTA partners lowers the response of a country pair's relative consumption growth to output growth by 0.11 (or 0.9 standard deviations). The result holds when we control for population, GDP per capita, and GDP volatility of the country pair. These variables do not appear to exhibit correlations with relative consumption growth.

We then focus on the sub-sample of country pairs who have ever participated in the same RTAs over the sample period. As is shown in Panel B, the absolute value of the coefficient estimate for the interaction term increases, which implies that RTAs play a more vital role in consumption risk sharing for countries that have a history of regional trade partnership.

Next we employ the panel approach with a fixed effects model to quantify the impact of RTAs. By including country-pair fixed effects, this approach controls for unobserved systematic differences across country pairs around RTA events. Table 2.2 Panel C reports the results. It demonstrates that the response of relative consumption growth to output growth decreases by 0.112 once a country pair joins an RTA. The coefficient estimate in this fixed effects model is similar in magnitude to that in the pooled regression for the full sample of country pairs.

In addition to these baseline findings, we conduct a robustness check. Since having access to broader goods and capital markets may change bilateral risk-sharing patterns, we control for country-pairs' ties with the rest of the world. To this end, we introduce the number of the GATT/WTO members from CEPII and financially-liberalized economies based on Bekaert et al. (2004) in the country-pair as as regressors. As is shown in Table 2.6.2, the GATT/WTO membership and financial liberalization do not appear to have a significant effect. Furthermore, the coefficient estimate for the interaction term with RTA and relative Output growth stays significant. The fact that our finding is robust to controlling for countries' financial liberalization status indicate that barriers in the trade channel remain to impede consumption risk sharing even if frictions in the asset market are taken into consideration.

To sum up, the coefficient estimate for the interaction term of RTA and relative output growth remains statistically and economically significant across alternative specifications. The finding supports the theory that reducing trade barriers promotes cross-country risk sharing.

Table 2.2: Bilateral Risk Sharing and RTA

Dep Var:	Pooled Regression						Panel Approach	
Δ Consumption	*A. Full Sample*			*B. RTA Sample*			*C. FE Model*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Output	0.302***	0.308***	0.308***	0.327***	0.455***	0.455***	0.302***	0.307***
	(0.005)	(0.005)	(0.005)	(0.012)	(0.013)	(0.013)	(0.005)	(0.005)
RTA		9.16e-17	8.02e-17		6.81e-18	2.17e-17		1.11e-16
		(0.000)	(0.000)		(0.001)	(0.001)		(0.001)
RTA × Δ Output		-0.111***	-0.111***		-0.259***	-0.259***		-0.112***
		(0.014)	(0.014)		(0.018)	(0.018)		(0.014)
GDP			1.11e-15			7.12e-15		
			(0.000)			(0.001)		
Population			-2.52e-15			-1.68e-14		
			(0.001)			(0.003)		
GDP volatility			-6.59e-16			1.03e-15		
			(0.000)			(0.001)		
Country Pair FE							Y	Y
Country FE	Y	Y	Y	Y	Y	Y		
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1,420,421	1,419,887	1,419,887	217,616	217,616	217,616	1,420,421	1,419,887
R-squared	0.208	0.209	0.209	0.224	0.255	0.255	0.183	0.185

The dependent variable is country i's relative consumption growth to that of country j. Δ Output is country i's relative output growth to that of country j. RTA is a dummy variable which is 1 when country i and j both participate in a regional trade agreement at t. Population is the product of the country pair's population at t in logs. GDP is the product of the country pair's GDP per capita at t in logs. GDP volatility is the product of the standard deviation of the two countries' per-capita GDP over time. The regressions include time fixed effects. In addition, pooled regressions include country fixed effects and the panel approach includes country-pair fixed effects. Clustered standard errors reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

2.3.2 A Gravity Model of Risk-sharing

After establishing the importance of trade costs for risk sharing by exploiting policy shifts, we derive a cross-sectional prediction for cross-country consumption allocations. In particular, we explore the implications of geographic distance for bilateral risk sharing.

The international economics literature has a long tradition of empirically studying how geographical distance influences economic linkages across countries. For instance, since being developed by Isard (1954) and Tinbergen (1962), the gravity model in international trade remains to be a workhorse due to its empirical success in predicting bilateral trade patterns. More recently, the gravity model has been applied to a growing range of areas to document that economic ties between two countries — including financial and migration flows — are inversely proportional to the geographic distance between them (e.g. Portes and Rey (2005) and Ramos and Surinach (2017)). Nevertheless, little is known about the impact of distance on macro fundamentals. Our paper fills the gap in the literature by focusing on consumption patterns.

The economic reasoning behind our hypothesis is straightforward. Trade costs increase with geographic distance: the farther away countries are located from one another, the higher trade costs it incurs to ship goods between them. If trade costs impede risk sharing, we should expect that country pairs with greater geographical distance in between exhibit weaker consumption risk sharing. Therefore, we hypothesize that there is a gravity model of consumption risk-sharing.

We test this hypothesis using a two-stage regression. In the first stage we compute the bilateral risk-sharing coefficients for all the country pairs using annual data over the sample period by estimating the equation:

$$\Delta log\ c_{it} - \Delta log\ c_{jt} = \alpha_{ij} + \beta_{ij}(\Delta log\ y_{it} - \Delta log\ y_{jt}) + \epsilon_{ijt}. \tag{2.3}$$

In the second stage we regress the estimated β_{ij} on geographic distance $dist_{ij}$:

$$\beta_{ij} = \alpha + \gamma\,(\ln dist_{ij}) + \epsilon_{ij}. \tag{2.4}$$

We will confirm the hypothesis if γ is positive, which implies that countries which are more distant from each other tend to exhibit a lower degree of consumption risk sharing. In addition to the baseline specification with distance only, we augment the analysis with standard gravity regressors including dummies for contiguity, common language, common legal system, and time-averaged product of population in logs and GDP per capita in logs. The values of these variables are sourced from the CEPII gravity database.

Table 2.3 reports the results of the second-stage regression. The coefficients for geographic distance are significantly positive across all the specifications. The estimates indicate that bilateral risk sharing decreases by about 0.01 (or 0.36 s.d.) for a 1% increase in geographic distance. The results obtain when other gravity variables are controlled for. Moreover, we find that bilateral risk sharing improves as a country-pair's economic size increases. From Column (4), a 1% increase in the product of GDP per capita raises bilateral risk sharing by 0.051. This result indicates that more economically developed countries are more likely to share risks with each other. Meanwhile, bilateral risk sharing decreases by 0.034 for a 1% increase in the product of population. One potential explanation is that, there is a higher level of intra-national risk sharing in a more populous economy which dampens the need for inter-national risk sharing. In terms of other gravity variables in Table 2.3, we find that sharing a common language promotes bilateral risk sharing, while having a common legal system yields less consistent results. When we control for country sizes, similarity in legal systems does appear to facilitate risk sharing as shown in column (4). In the same column the coefficient estimate for contiguity is positive, which contradicts our expectation that country pairs that share borders should exhibit stronger risk sharing.

However, contiguity does promote risk sharing when geographic distance is controlled for, as suggested by the sign of the interaction term in column (4). To sum up the main findings in Table 2.3, we confirm that the signs of distance and GDP in this gravity model of consumption risk sharing are the same as those in other gravity models including trade, finance, and migration.

Table 2.3: A Gravity Model of Risk-sharing

Dep Var: β_{ij}	(1)	(2)	(3)	(4)
Distance	0.011***	0.014***	0.009***	0.007***
	(0.002)	(0.003)	(0.002)	(0.002)
Contiguity		0.142***		0.033***
		(0.012)		(0.012)
Language		-0.063***		-0.016***
		(0.005)		(0.005)
Legal		0.008*		-0.033***
		(0.004)		(0.004)
GDP			-0.050***	-0.051***
			(0.001)	(0.001)
Population			0.035***	0.034***
			(0.001)	(0.001)
Constant	0.481***	0.458***	0.319***	0.384***
	(0.021)	(0.022)	(0.032)	(0.033)
Observations	31,684	31,659	31,684	31,659
R-squared	0.001	0.008	0.224	0.226

The dependent variable is the estimated coefficient β from the first stage regression. Higher β suggests weaker consumption risk sharing. Independent variables include the log of geographic distance between two countries in kms, dummies for common language, legal system, contiguity, and time-averaged product of population in logs, and GDP per capita in logs. Standard errors reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

In the next step we conduct two sensitivity analyses to verify the robustness of the gravity model. Specifically we consider an alternative measure of distance and a more robust measure of risk sharing.

The benchmark measure of geographic distance between two countries comes from the CEPII, which calculates population-weighted distance between the biggest cities of those two countries. For robustness, we also consider simple distance calculated with the geographical coordinates of the capital cities. Results reported in Table 2.6.3 suggest that the results remain unchanged.

Furthermore, we address a potential concern with our measure of risk sharing. In Equation 2.3 where we define and estimate the risk-sharing coefficients, we use the difference in output growth between a pair of countries (denoted as $\Delta log\ y_{it} - \Delta log\ y_{jt}$) to reflect the countries' idiosyncratic risks. By doing so, we implicitly assume that the two countries have the same degree of exposure to the global shocks. In other words, when loadings of aggregate shocks (denoted as β_i, β_j) are the same, the difference in idiosyncratic risks can be written as

$$(\Delta log\ y_{it} - \beta_i \Delta log\ y_{wt}) - (\Delta log\ y_{jt} - \beta_j \Delta log\ y_{wt}) = \Delta log\ y_{it} - \Delta log\ y_{jt}, \tag{2.5}$$

where y_{wt} is the world output per capita. However, this assumption is not valid in some cases so that the difference in output growth is also driven by the countries' distinct degrees of exposure to world aggregate risks. To address this concern, we conduct a robustness check where we adjust for countries' different loadings of aggregate risks. First we estimate β_i, β_j from

$$\Delta log\ y_{it} = \alpha_i + \beta_i \Delta log\ y_{wt} + \epsilon_{it}, \qquad \Delta log\ y_{jt} = \alpha_j + \beta_j \Delta log\ y_{wt} + \epsilon_{jt}. \tag{2.6}$$

Second we calculate bilateral risk-sharing coefficients from the response of consumption to obtain a more robust measure of idiosyncratic output shocks:

$$\Delta log\ c_{it} - \Delta log\ c_{jt} = \alpha_{ij} + \beta_{ij}[(\Delta log\ y_{it} - \beta_i \Delta log\ y_{wt}) - (\Delta log\ y_{jt} - \beta_j \Delta log\ y_{wt})] + \epsilon_{ijt}. \quad (2.7)$$

Lastly we regress the estimated β_{ij} on geographic distance.

$$\beta_{ij} = \alpha + \gamma\,(\ln dist_{ij}) + \epsilon_{ij}. \quad (2.8)$$

Table 2.4 presents the result for this robustness check. Compared to Table 2.3, the coefficient estimates have identical signs and similar values. The magnitude of the coefficient for distance is greater by about 0.003, indicating that geographic distance plays a more crucial role in shaping risk sharing patterns when we control for countries' different exposure to world aggregate risks. The gravity model of risk sharing remains robust.

Table 2.4: Gravity model - Robustness check

Dep Var: β_{ij}	(1)	(2)	(3)	(4)
Distance	0.014***	0.019***	0.012***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)
Contiguity		0.145***		0.039***
		(0.012)		(0.012)
Language		-0.059***		-0.014***
		(0.005)		(0.005)
Legal		0.020***		-0.021***
		(0.004)		(0.004)
GDP			-0.051***	-0.052***
			(0.001)	(0.001)
Population			0.033***	0.033***
			(0.001)	(0.001)
Constant	0.453***	0.415***	0.369***	0.411***
	(0.020)	(0.022)	(0.031)	(0.033)
Observations	31,684	31,659	31,684	31,659
R-squared	0.001	0.008	0.225	0.226

The dependent variable is the estimated coefficient β from the first stage regression. Independent variables include the log of geographic distance between two countries in kms, dummies for colony, common language, legal system, and time-averaged product of population in logs, GDP per capita in logs, and GDP p.c. volatility. Standard errors reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

2.3.3 Gravity Model and RTA

As the last part of the empirical analysis, we bring all the previous pieces together and study the relationship between the gravity model of risk-sharing and regional trade agreements (RTA). The finding will allow us to examine the impact of policy obstacles in the trade channel on the lack of efficient risk sharing across countries.

Theoretically in a frictionless world, bilateral risk sharing should not be correlated with geographical distance among countries. All the countries share risks perfectly regardless of the physical distance among them. Nevertheless, there exist frictions that positively comove with distance in the channels of risk sharing. For example, shipping costs in trade, informational asymmetries in finance, migration cost in labor mobility are factors that prohibit the channels from working efficiently to ensure perfect risk sharing. These frictions rise with geographic distance, making risk sharing across country pairs that are physically distant from each other increasingly difficult. These frictions can justify the gravity model established in the previous section.

This paper focuses on trade in the goods market as a channel for risk sharing, but frictions increase with geographic distance in various channels. Therefore, we need additional empirical evidence to build the causal link between trade and the gravity model. To this end, we exploit variations in RTAs as in Section 3.1 in order to attribute the gravity model of risk sharing to the trade channel.

Besides the lower shipping costs due to the shorter traveling distance, countries that are physically closer to each other obtain better risk sharing through trade since they typically face fewer trade policy distortions under RTAs. RTAs are usually signed to reduce trade barriers including tariffs and quotas in order to protect the common economic interest of a geographic region. If the trade channel contributes to risk sharing across countries, we should expect that geographic distance poses a smaller obstacle for risk sharing in the presence of RTAs.

To test this hypothesis we estimate the following specification:

$$\begin{aligned}
\Delta log\ c_{it} - \Delta log\ c_{jt} &= \alpha + \beta_1(\Delta log\ y_{it} - \Delta log\ y_{jt}) + \beta_2(ln\ dist_{ij}) \\
&+\beta_3(RTA_{ijt}) + \beta_4(RTA_{ijt} \times ln\ dist_{ij}) \\
&+\beta_5[RTA_{ijt} \times ln\ dist_{ij} \times (\Delta log\ y_{it} - \Delta log\ y_{jt})] \\
&+\eta_t + \eta_i + \eta_j + \epsilon_{ijt}.
\end{aligned} \tag{2.9}$$

In this specification we are particularly interested in β_5, the coefficient for $RTA \times log\ dist \times \Delta y$. A negative β_5 implies that geographic distance impedes risk sharing to a less extent for a pair of countries when they participate in a regional trade agreement.

The results presented in Table 2.5 confirm this hypothesis. The coefficients for the three-way interaction term are significantly negative across all the regression specifications. Based on the coefficient estimates, a 1% increase in geographic distance lowers consumption risk sharing by 0.016 (or 0.13 s.d.) more in the absence of RTAs. The interpretation of the find is that, if geographic distance is a proxy for barriers to risk sharing, RTAs overcome these barriers regardless of distance. This finding remains robust when I add dummies for contiguity, common language, common legal system, and time-averaged product of population in logs, GDP in logs, and GDP volatility in the regressions. These standard gravity controls do not show significant correlations with cross-country relative consumption growth. The only variable that has a significant coefficient other than the three-way interaction term is the relative output growth, implying that the failure of consumption risk sharing is not fully explained by the listed variables. This could be driven by the fact that there exist frictions in other channels of consumption risk sharing.

Moreover, we conduct an exercise with two stage least squares (2SLS) in order to further identify the mechanism through which distance and RTA affect risk sharing. To implement 2SLS, we project trade with all the gravity variables including distance and RTA in the first step. As a second step we include the projected trade as a control variable when testing regression 2.9. As reported in Table 2.6.4, the coefficient for the interaction term with RTA, distance and relative output growth is no longer significant. This finding establishes the causality that RTA and distance affect consumption patterns through their influence on trade.

Based on these results, we confirm our hypothesis that one important channel through which we justify the gravity model established earlier is trade in goods. Geographic distance matters for risk sharing because they covary with trade costs. Hence once trade-promoting policies are considered, distance becomes less relevant in shaping consumption risk sharing patterns. Furthermore, distance and RTA no longer matter for consumption once we control for their impact on trade.

These findings support the main argument of the paper that trade costs impede consumption risk sharing across countries. Therefore, efforts to lift trade barriers will strengthen countries' ability to share risks and smooth consumption.

Table 2.5: Gravity Model with RTA

Dep Var: Δ Consumption	Pooled Regression			Panel Approach
	(1)	(2)	(3)	(4)
Δ Output	0.309***	0.310***	0.310***	0.308***
	(0.005)	(0.005)	(0.005)	(0.005)
RTA	-1.90e-11	-2.11e-11	-2.12e-11	-3.28e-11
	(0.002)	(0.002)	(0.002)	(0.005)
RTA × Distance	2.61e-12	2.86e-12	2.86e-12	4.33e-12
	(0.000)	(0.000)	(0.000)	(0.001)
RTA × Distance × Δ Output	-0.016***	-0.016***	-0.016***	-0.016***
	(0.001)	(0.001)	(0.001)	(0.002)
Contiguity		1.66e-12	1.67e-12	
		(0.000)	(0.000)	
Language		5.12e-14	5.28e-14	
		(0.000)	(0.000)	
Legal		1.25e-13	1.32e-13	
		(0.000)	(0.000)	
GDP			-3.90e-13	
			(0.000)	
Population			4.24e-13	
			(0.001)	
GDP volatility			9.04e-14	
			(0.000)	
Constant	-7.20e-13	-8.57e-13	-4.16e-12	-1.68e-13
	(0.001)	(0.001)	(0.013)	(0.001)
Country Pair FE				Y
Country FE	Y	Y	Y	
Time FE	Y	Y	Y	Y
Observations	1,419,887	1,418,802	1,418,802	1,419,887
R-squared	0.210	0.211	0.211	0.195

The dependent variable is country i's relative consumption growth to that of country j. Δ Output is country i's relative output growth to that of country j. Independent variables include the log of geographic distance between two countries in kms, a dummy for RTA which is 1 when country i and j both participate in a regional trade agreement at t, dummies for contiguity, common language, legal system, and time-averaged product of population in logs, GDP p.c. (per capita) in logs, and GDP p.c. volatility. The regressions include time fixed effects. In addition, pooled regressions include country fixed effects and the panel approach includes country-pair fixed effects. Clustered standard errors reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

2.4 Conclusion

By exploiting cross-sectional and time-series variations in trade costs amongst country pairs, this paper empirically evaluates the role of trade costs in explaining the lack of international consumption risk sharing. We obtain three major findings from a large panel of countries over the period 1970-2014. First, bilateral risk sharing improves once a pair of countries become partners under a regional trade agreement. Moreover, a gravity model of consumption risk sharing obtains since bilateral risk sharing decreases in geographical distance between countries. In addition, this effect is more pronounced in the absence of regional trade agreements. All the evidence supports the argument that trade costs impede cross-country risk sharing.

This paper contributes to the growing literature that extends the gravity model of trade to other topics including migration, financial flows, and exchange rate determination among others. Since these cross-country economic linkages also play an essential role in international risk sharing, disentangling the influence of each channel can help us better understand the global consumption pattern. Fitzgerald (2012) sets a nice example by quantifying financial frictions and trade costs in explaining the lack of cross-country risk sharing. Future work should incorporate other channels to account for the growing interdependence across countries. Counterfactual analysis based on such structural frameworks will allow us to measure the contribution of each channel to cross-country risk sharing. In terms of policy implications, these papers call for the need of policies that aim to reduce the frictions in the channels of risk sharing. Doing so will allow the global community to yield welfare gains by reducing the overall consumption volatility.

2.5 References

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2.6 Appendices

Table 2.6.1: List of Countries

Country	Num of RTAs	Num of partners
Albania	4	39
Algeria	2	69
Angola	2	21
Anguilla	1	28
Antigua n Barbuda	2	42
Argentina	7	44
Armenia	7	9
Aruba	1	28
Australia	10	27
Austria	41	105
Azerbaijan	5	6

Bahamas	2	42
Bahrain	4	17
Bangladesh	7	52
Barbados	2	42
Belarus	4	7
Belgium	44	105
Belize	2	42
Benin	3	52
Bermuda	1	28
Bhutan	4	7
Bolivia	5	43
Bosnia	3	35
Botswana	3	16
Brazil	8	46
Brunei Darussalam	8	16
Bulgaria	39	105
Burkina Faso	2	14
Burundi	4	16
Cambodia	6	15
Cameroon	3	74
Canada	10	14
Cape Verde	1	14

Cayman Islands	1	28
Central African	1	5
Chad	1	5
Chile	27	91
China	13	23
Colombia	11	80
Comoros	2	16
Congo	2	6
Congo, D.R.	0	0
Costa Rica	13	44
Côte d'Ivoire	2	14
Croatia	38	105
Cyprus	40	105
Czech Republic	40	105
Denmark	44	105
Djibouti	1	1
Dominica	2	42
Dominican Republic	4	35
Ecuador	6	71
Egypt	9	105
El Salvador	11	39
Equatorial Guinea	1	5

Estonia	40	105
Ethiopia	2	16
Fiji	4	42
Finland	41	105
France	44	105
Gabon	1	5
Gambia	1	14
Georgia	10	37
Germany	44	105
Ghana	2	52
Greece	43	105
Grenada	2	42
Guatemala	10	38
Guinea	2	52
Guinea-Bissau	1	14
Haiti	1	14
Honduras	11	39
Hong Kong	4	7
Hungary	40	105
Iceland	29	61
India	18	52
Indonesia	8	48

Iran	2	42
Iraq	2	51
Ireland	44	105
Israel	8	49
Italy	44	105
Jamaica	2	42
Japan	13	15
Jordan	8	51
Kazakhstan	7	8
Kenya	4	16
Kuwait	3	16
Kyrgyzstan	6	8
Lao	9	17
Latvia	40	105
Lebanon	3	47
Lesotho	4	25
Liberia	1	14
Lithuania	40	105
Luxembourg	44	105
Macao	1	1
Macedonia	5	40
Madagascar	2	29

Malawi	3	21
Malaysia	13	48
Maldives	3	7
Mali	2	14
Malta	40	105
Mauritius	6	51
Mexico	20	85
Moldova	7	43
Mongolia	0	0
Montserrat	2	42
Morocco	8	85
Mozambique	2	51
Myanmar	7	48
Namibia	3	16
Nepal	4	7
Netherlands	44	105
New Zealand	10	28
Nicaragua	10	76
Niger	2	14
Nigeria	2	52
Norway	28	60
Oman	4	17

Pakistan	10	52
Palestine	3	33
Panama	16	44
Paraguay	7	21
Peru	17	84
Philippines	9	53
Poland	40	105
Portugal	42	105
Qatar	3	16
Romania	39	105
Russia	8	12
Rwanda	4	16
Saint Lucia	2	42
Sao Tome	0	0
Saudi Arabia	3	16
Senegal	2	14
Seychelles	3	41
Sierra Leone	1	14
Singapore	22	63
Slovakia	40	105
Slovenia	40	105
South Africa	4	44

South Korea	14	84
Spain	42	105
Sri Lanka	8	47
St. Kitts	2	42
St. Vincent n Grenadines	2	42
Sudan	4	64
Suriname	2	42
Swaziland	5	25
Sweden	41	105
Switzerland	29	62
Syria	3	44
Taiwan	6	7
Tajikistan	2	7
Tanzania	5	58
Thailand	12	48
Togo	2	14
Trinidad n Tobago	3	82
Tunisia	7	88
Turkey	20	57
Turkmenistan	5	6
Turks n Caicos	1	28
U.A.E.	4	16

Uganda	4	16
Ukraine	17	45
United Kingdom	44	105
United States	14	15
Uruguay	7	21
Uzbekistan	4	6
Venezuela	4	43
Viet Nam	9	48
Virgin Islands	1	28
Yemen	1	15
Zambia	3	21
Zimbabwe	5	86

This table reports the list of countries in our sample. For the countries that participated in any regional trade agreement (RTA) from 1950 to 2014, we list the number of RTAs they were a member of, the number of countries that were ever their partners in any RTA, and the average duration (in years) of RTAs they participated in. Source: WTO.

Table 2.6.2: Bilateral Risk Sharing and RTA — Robustness

Dep Var:	Pooled Regression		Panel Approach
Δ Consumption	*A. Full Sample*	*B. RTA Sample*	*C. FE Model*
	(1)	(2)	(3)
Δ Output	0.316 ***	0.464 ***	0.307 ***
	(0.003)	(0.009)	(0.005)
RTA	5.48E-17	1.38E-17	9.64E-18
	(0.000)	(0.001)	(0.001)
RTA $\times$ Δ output	-0.117 ***	-0.266 ***	-0.112 ***
	(0.009)	(0.012)	(0.014)
WTO	5.09E-17	-1.44E-18	-7.61E-17
	(0.000)	(0.000)	(0.000)
BHL	-4.86E-17	-2.18E-17	-7.30E-17
	(0.000)	(0.000)	(0.000)
Year FE	Y	Y	Y
Observations	1,419,887	217,616	1,419,887
R-squared	0.194	0.246	0.194

The dependent variable is country i's relative consumption growth to that of country j. Δ Output is country i's relative output growth to that of country j. RTA is a dummy variable which is 1 when country i and j both participate in a regional trade agreement at t. WTO and BHL denote the number of the GATT/WTO members and financially-liberalized economies based on Bekaert et al. (2004) in the country-pair. The regressions include time fixed effects. Clustered standard errors reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

Table 2.6.3: A Gravity Model of Risk-sharing — Robustness with Alternative Distance

Dep Var: β_{ij}	(1)	(2)	(3)	(4)
Distance	0.012***	0.009***	0.015***	0.008***
	(0.002)	(0.002)	(0.003)	(0.002)
GDP		-0.050***		-0.051***
		(0.001)		(0.001)
Population		0.035***		0.034***
		(0.001)		(0.001)
Language			-0.063***	-0.016***
			(0.005)	(0.005)
Legal			0.008*	-0.033***
			(0.004)	(0.004)
Contiguity			0.114	0.487***
			(0.106)	(0.115)
Contg $\times$ Dist			0.005	-0.067***
			(0.016)	(0.017)
Constant	0.475***	0.320***	0.451***	0.371***
	(0.021)	(0.031)	(0.022)	(0.033)
Observations	31,684	31,684	31,659	31,659
R-squared	0.001	0.224	0.008	0.227

The dependent variable is the estimated coefficient β from the first stage regression. Higher β suggests weaker consumption risk sharing. Independent variables include the log of geographic distance between two countries in kms, dummies for common language, legal system, contiguity, and time-averaged product of population in logs, and GDP per capita in logs. Standard errors reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

Table 2.6.4: A Gravity Model of Risk-sharing — Robustness with Projected Trade

Dep Var: Δ Consumption	Pooled Regression			Panel
	(1)	(2)	(3)	(4)
Δ Output	0.138***	0.138***	0.138***	0.135***
	(0.005)	(0.005)	(0.005)	(0.005)
RTA	-0.001	-4.37E-04	-0.001	2.23e-4
	(0.003)	(0.003)	(0.003)	(0.008)
RTA $\times$ Distance	1.07E-04	1.33E-05	3.28E-05	-1.15e-4
	(0.000)	(0.000)	(0.000)	(0.001)
RTA $\times$ Distance $\times$ Δ Output	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
$\widehat{Trade}$	2.35E-04	3.21E-04	3.35E-04	5.19e-4
	(0.000)	(0.000)	(0.000)	(0.000)
Contiguity		-7.55E-04	-7.96E-04	
		(0.001)	(0.001)	
Language		-2.56E-04	-2.52E-04	
		(0.000)	(0.000)	
Legal		-1.13E-04	-8.16E-05	
		(0.000)	(0.000)	
GDP			-9.45E-04	
			(0.002)	
Population			0.002	
			(0.003)	
GDP volatility			4.09E-04	
			(0.001)	
Constant	-0.004	-0.006	-0.05	-0.01
	(0.005)	(0.005)	(0.055)	(0.007)
Country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	431,132	431,132	431,132	431,132
R-squared	0.112	0.112	0.112	0.0839

The dependent variable is country i's relative consumption growth to that of country j. Δ Output is country i's relative output growth to that of country j. Independent variables include the log of geographic distance between two countries in kms, a dummy for RTA which is 1 when country i and j both participate in a regional trade agreement at t, log of trade projected by gravity variables (denoted as $\widehat{Trade}$), dummies for contiguity, common language, legal system, and time-averaged product of population in logs, GDP p.c. (per capita) in logs, and GDP p.c. volatility. The regressions include time fixed effects. Clustered standard errors reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

Chapter 3

Deviations from Covered Interest Rate Parity: evaluating drivers from changes

3.1 Deviations from CIP and Global Financial Crisis

The foreign exchange (FX) market is a significant part of the financial markets. It allows one country's money exchange for another, defining the exchange rate between them. Derived from comparing exchange rates and interest rate differentials, the theoretical concept of covered interest rate parity (CIP) holds when there are no arbitrage opportunities among these financial instruments. Despite this theoretical assumption, and its use in open economy and monetary models, empirical research has shown that CIP does not necessarily hold in practice.

Before the Global Financial Crisis (GFC), CIP was observed for most advanced economies. Small deviations from it were arbitraged in the short run. However, after the GFC, large and persistent deviations were observed for the most liquid currencies in the FX market. This research empirically studies the deviation from CIP and the possible drivers for this phenomenon over a set of advanced market economies.

Some factors that can cause the deviation ("basis") and the incapacity of being arbitraged away have been identified in the literature. They are usually explained by: transactions costs, counter-party credit risk, lack of liquidity in secondary markets, and d) lack of funding due to systemic withdrawal by short-term lenders in a currency. Different papers have tried to explain the deviations by using models and/or empirical analysis to explain and quantify it. Funding shortage and counterparty risk are present in most of the post-GFC literature as important factors.

Between 2001 and 2007, the world economy experienced a period of stability and growth, followed by a global financial crisis and a period of dollar squeeze in 2008-2012. As the most liquid currency, several international banks increased their holdings of US dollar assets. This dollar funding was raised, primarily, through market operations: the bank raises domestic currency through deposits and lends them against US dollars. In normal times, it is done through the interbank market, operations with central banks, and FX swaps to convert domestic currency funding into dollars. With the financial crisis and the Lehman Brothers bankruptcy, lenders became risk averse, increasing the difficulty of keeping these operations active.

Several research papers present in their theoretical models and empirical analysis an important role for intermediaries. Despite the theoretical assumption of costless arbitrage, the actual no arbitrage condition requires a lot of resources, and regulatory requirements also raise the its cost. Before the crisis, the collateral and margining requirements for arbitraging interest rates and exchange rate differentials were much less prohibitive in balance sheet requirements.

Given the scenario of positive basis in some currencies, the understanding of possible causes is an interesting and current research question. I begin this paper with a selected and critical literature review of theoretical models, empirical analysis and stylized facts developed to explain currency basis. With this map, I am able to identify the literature gaps and establish my contributions. My main contribution is to analyze post GFC period in a cross-country setup. Most of the work has been done for specific currencies like US dollar, Euro and Japanese Yen, and this broader approach aims to compare deeply the drivers for the deviation. Additionally, the channels in the literature have been evaluated in single fashion, i.e., added in some theoretical model alone. I have claimed to see how relevant the channels still remain when evaluated together.

Based on data from Bloomberg, the World Bank, and the Bank of International Settlement (BIS), I have tested how several variables might get potential explanations for the deviations in a different set of countries. The following sections start with the literature review - divided before and after the GFC (and this last period grouped by theoretical and empirical evidences). After that, I present the methodology and data, as well as justifications for the choices. Then the results are presented, and the paper concluded.

3.2 CIP analysis through time

The CIP literature can be divided in two periods: before and after the 2008 GFC. In the first period, CIP was empirically confirmed to hold in practice. This means that small deviations were arbitraged away in short durations. After the 2008 crisis, some papers identified substantially deviations, and these basis have been showing persistent behavior, raising questions about the CIP concept. A large literature tests the CIP condition before the global financial crisis and documents large CIP deviations during the crisis. This work focuses on the post 2008 period.

3.2.1 Theoretical evidence

A considerable part of the literature, besides identifying the deviations on CIP, proposed models to explain them. Several mechanisms serve as motivation for the modeling exercise: currency as a scarce good, banking lending behavior, application to monetary policy and zero lower bound, and corporate funding cost arbitrage (Bottazzi et al. (2013); Ivashina et al. (2015); Amador et al. (2016); Liao (2016)). Some models approached the problem by using a dynamic general-equilibrium model with margin constraints (Garleanu & Pedersen, 2011). The CIP deviation may also be some component of a model with a distinct primary goal, such as exchange rate determination (Gabaix and Maggiori, 2015). Below, I add more details of the theoretical development.

As the channels of liquidity during the crisis were scarcer, a model proposed by Bottazzi et al. (2013) proposed the cross-currency basis (which captures the deviations from CIP) as the relative value of the scarcer currency. This hypothesis was able to match the data, by checking collaterals as funding constraints. In a crisis, banks are more reluctant to lend a scarcer currency, and it is priced into the cross-currency basis.

Ivashina et al. (2015) approached the problem by the credit quality of the banks, that ultimately work as intermediaries for these operations. Using the financial friction as a way to sharp bank behavior, this channel also matches the data.

The zero-lower bound (ZLB) limitation faced in the crisis was also explored as a channel for explaining the deviation from CIP. The constraint on nominal interest rates works as a source of limitation to arbitrage (Amador et al. (2016)). Liao (2016) examined the issue through the lens of corporate fund cost. To explain it, the author developed a model of market segmentation, in which post-crisis regulations and intermediary frictions hampered arbitrage.

Garleanu and Pedersen (2011) had a similar approach as Liao (2016), which was aimed for explaining deviations from LOOP. In their reasoning, a funding-liquidity crisis raises the price gaps between securities with identical cash-flows but different margins. Gabaix and Maggiori (2015) explored the topic in a model with moral hazard and imperfect financial markets.

The banking regulation evidence is developed in models of intermediary-based asset pricing (He and Krishnamurty (2012); Brunnermeier and Sannikov (2014)). Additionally, Gromb and Vayanos (2010) survey offers useful information on limits to arbitrage, Brunnermeier and Pedersen (2009) on funding liquidity, Vayanos and Vila (2009) and Greenwood and Vayanos (2014) on preferred habitat.

3.2.2 Empirical evidence

The literature on deviations from CIP also contains papers with a purely empirical approach, without focusing on developing new models. In this section, I present some of these papers and their methodology. This section will be important for discussing proxies, identification of the basis, and measurement analysis.

Baba et al. (2008) analyzed the deviation in money markets in the second half of 2007. They identified the use of swap markets to circumvent US dollar funding shortages and linked it with deviations from CIP. Their analysis contemplated a small window of 2007 and 2008.

Coffey et al. (2009) explored margin conditions and the cost of capital as drivers of CIP deviations, especially during the crisis period. With increasing uncertainty about counterparty risk and scarcer swap lines, a breakdown of arbitrage transactions in the international capital markets was evaluated.

Adding more emphasis in the post-crisis period, Du et al. (2017) identified the CIP deviations as a combination of cost of financial intermediation and international imbalances in investment demand and funding supply across currencies. Costly financial intermediation can explain why the basis is not arbitraged away post crisis.

Rime et al. (2016) also focused on the role of money market segmentation on CIP deviations. With funding liquidity differences, it becomes impossible for FX swap intermediaries to supply the markets without eliminating arbitrage conditions.

Sushko et al. (2016) linked the estimated dollar hedging demand (quantities) to the variation in CIP deviations (prices). The authors argue that the degree to which CIP holds depends more the relationship between the forward and spot price than the interest rate differential, by showing that the CIP deviations rely mostly to hedge the USD forward. This is explained by the cost associated to this hedge over regulatory aspects: it causes some allocation on the balance sheet. With limits to arbitrage, CIP arbitrageurs charge a premium in the forward markets for taking the other side of FX hedgers' demand in proportion to their balance sheet exposure. This will allow us to proxy the USD funding needs in FX swap markets by banks through the financial system net liabilities.

3.3 Methodology and Data

By mapping all the different approaches and proxies discussed in the literature, it is interesting to check how this proxies perform together and across a larger set of countries, instead of a particular one. Being able to identify possible the "top drivers" to the phenomena has immediate applications to policy makers, like monetary authorities. Potential candidates for drivers are justified theoretically from the economic and financial literature. The argument above are explained in the following two bullets:

- Are the variables used as possible drivers in the literature extensible to the new set of countries?

- What are the commonalities and differences in the deviations from CIP among countries?

Some common explaining factors can be identified in the literature about deviation for CIP, regardless of whether they have a theoretical or empirical approach. According to literature review, liquidity and counterparty risk play a big role in driving these deviations, but other factors might help explain it (demand for US dollars, risk from global banks, financial variables).

Traditionally, this deviations were around zero in developed countries, and it seems reasonable the recent literature focuses over the most relevant currencies in the FX market, like US dollar, Euro, and Japanese Yen. Nevertheless, according to the Bank of International Settlement (BIS) Foreign Exchange Survey realized in 2019 (BIS, 2019), the group composed by Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), Pound Sterling / British Pound (GBP), and Singapore dollar (SGD), respond for approximately 25% of the daily turnover on the foreign exchange market (table 1 below). Given this relevance and the trend of participation, it is interesting to check how deviations from CIP behaved for this group.

Table 3.3.1: OTC foreign exchange turnover by currency pair

Currency pair	2007		2010		2013		2016		2019	
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
USD / EUR	892	26.8	1099	27.7	1292	24.1	1172	23.1	1584	24.0
USD / JPY	438	13.2	567	14.3	980	18.3	901	17.8	871	13.2
USD / GBP	384	11.6	360	9.1	473	8.8	470	9.3	630	9.6
USD / AUD	185	5.6	248	6.3	364	6.8	262	5.2	358	5.4
USD / CAD	126	3.8	182	4.6	200	3.7	218	4.3	287	4.4
USD / CHF	151	4.5	166	4.2	184	3.4	180	3.6	228	3.5
USD / SGD	-	-	-	-	65	1.2	81	1.6	110	1.7

Source: Bank of International Settlements -Triennial Central Bank Survey on Foreign Exchange and OTC. Net-net basis, daily averages in April, in billions of US dollars and percentages, adjusted for local and cross-border inter-dealer double-counting. I have omitted the pairs USD/CNY (Chinese Yuan), USD/HKD (South Korean Won) and USD/INR (Indian Rupee) with 4.1%, 3.3% and 1.7% of participation in 2019 due to lack of information for the calculations executed.

It is a relevant research question to investigate how the deviations from CIP behaved for these currencies, and to investigate if the same factors found on the literature can be applied to this new set. In the scenario where similar evidence is found, it is possible to extend the reach of the models that absorb these stylized facts to a wider range of countries. If the empirical behavior for this new set of currencies shows a different outcome, then a natural consequence of the research would be to explore other possible factors that might explain such behavior, and how the existing models can be extended to absorb such behavior in that group.

As the analysis was conducted with linear regressions, the possible limitations of heteroskedasticity was contemplated by robustness on the errors. Despite the fact that these variables could be evaluated as time series, these are mostly financial instruments and concepts constructions (like bid-ask spread, terms of trade), or institutional statistic (bank concentration). To enhance the results interpretation, I have added a lagged term for the cross-currency basis. The high frequency of the data adds much noise to the evaluation. Even considering it, it's safe to assume that the simple model proposed captures significant part of the variance – with R-squared close to 1 for the countries sample).

Finally, due to some differences in the time frame for the variables – some were available in daily basis, while others were available as year basis [1]- the analysis was conducted over levels, and not changes. This is the reason why the discussion was concentrated over the signs and not the dimension of the coefficients.

3.3.1 The variables[2]

In this section, I will present, discuss, and justify the variables selected for my analysis. The research question of this paper is to evaluate possible drivers for deviation for

[1] The banking concentration, for example, was given as a year number. I have conducted a cubic spline interpolation for quarterly frequency to add some disturbance. It wouldn't make economic sense to transform it to daily frequency, as the bank concentration doesn't change that fast. This fact limited the change analysis of the variables, so I have concentrated only on the interpretation of the coefficient signs.

[2] Following the literature, I have also considered as proxies: volume of currency pairs(liquidity), demand for USD (risk), implied volatility and risk-reversal-25-Delta (financial). All these variables have a high correlation with the covariates used and haven't added explanation power to the results. For space limitation, I have maintained them out of the results showed, but they are available upon request.

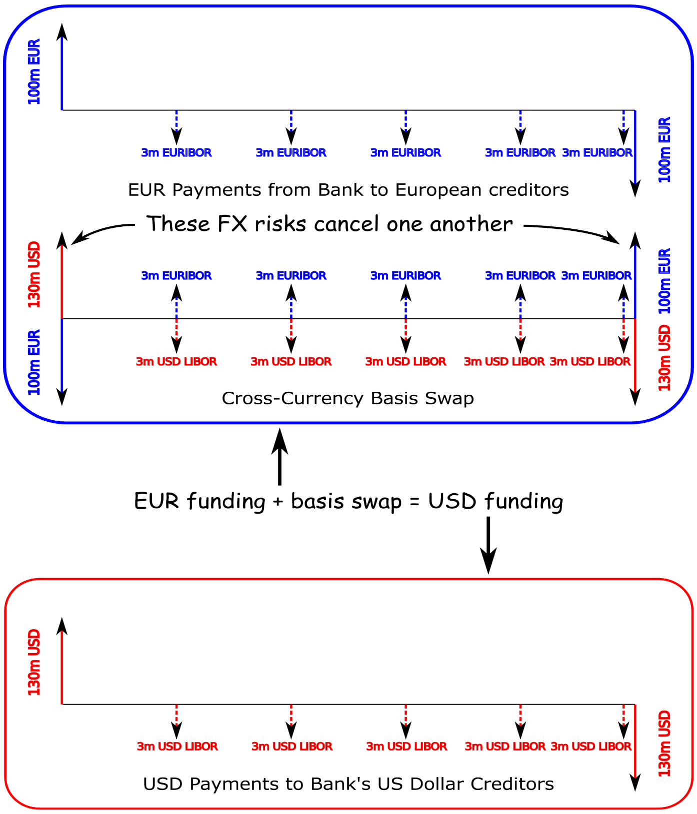
CIP for the selected countries. The first step is to measure the basis over these currencies. For this, I will use the approach of Du et al. (2017) on considering the basis as the spread between cross-currency swap and USD Libor.

Basis and Cross-Currency Swaps

Following Nakisa (2011), we establish an example to understand the banking role in the FX swap market.

"Let's take the scenario of European banks with liabilities in dollars. As the euro falls against the dollar, the cost of these payments increases. The situation is worsened by US investors fear to lend to any European firms and banks. Through a cross-currency swap, banks can raise funding in Europe in euro and transform this into dollars at a fixed currency exchange rate that is agreed up front. The basis swap will allow the bank to transform their dollar liability into a euro liability they can fund more easily. The cross-currency basis swap will convert the lump sum that the bank borrowed in euros into a lump sum in dollars. The counterparty in the cross-currency basis swap will actually pay the bank a little less than the euro rate and pocket the difference between the euro rate and the rate on the swap. If banks are desperate for dollar funding, they will be willing to receive less interest on the euro interest on the swap. Cross-currency basis swaps are quoted as this difference in interest received. Turning this around, it is extremely cheap for US banks to convert euro liabilities into dollars. Then, the cross-currency basis swap rate measures deviations from the CIP condition where interest rates are Libor interest rate swap rates."

Figure 3.3.1: Cross Currency Swap and Basis



Source: Nakisa (2011).

Table 3.3.2: Basis evaluation

Dollar Demand vs. Euro	Basis Swap Rate	Swap EUR → USD	Swap USD → EUR
High	Decrease (more negative)	More expensive	Less expensive
Low	Increase (more positive)	Less expensive	More expensive

Source: Nakisa (2011).

As demand for dollar funding has increased the euro dollar basis swap rate has fallen sharply and has become strongly negative. The data collected from Bloomberg for the currencies selected was compiled in the tables below for one year of maturity.

The literature review argued an increase on the deviations from CIP after the GFC, with some persistent behavior. Following Coffey et al. (2009) and Du et al. (2017), the period break proposed to analyze the deviation is composed by two intervals: the first part goes from January 1st, 2000 to September 15th, 2008, the official bankruptcy date of the Lehman Brothers. The second period goes from September 16th, 2008 until December 31st, 2018. The averages and standard deviation are presented on table 3 and illustrated on figures 2 and 3.

Table 3.3.3: Summary Statistics for Cross-Currency Swap Basis Points

Panel A: Whole period (01.01.2000 - 12.31.2018)

Cross-currency swap Basis Points	Whole period (01.01.2000 - 12.31.2018)				
	Mean	SD	Min	Max	N
Australian dollar	9.33	6.91	(71.00)	40.00	4,936
Canadian dollar	(2.11)	11.98	(37.50)	37.00	4,746
Swiss Franc	(16.70)	17.13	(82.12)	3.25	4,666
British Pound	(7.72)	12.48	(116.60)	11.60	4,725
Singaporean dollar	(3.23)	3.61	(35.00)	9.73	4,330

Panel B1: Period I - Before Lehman Brothers Bankruptcy (01.01.2000 - 09.15.2008)

Cross-currency swap Basis Points	Per. I - Before Lehman Brothers Bankruptcy				
	Mean	SD	Min	Max	N
Australian dollar	5.19	2.01	(8.00)	10.70	2,230
Canadian dollar	7.10	3.22	(1.00)	21.00	2,041
Swiss Franc	(0.67)	4.10	(24.00)	3.25	1,959
British Pound	(1.70)	4.76	(32.40)	5.00	2,021
Singaporean dollar	(2.46)	3.07	(25.00)	4.00	1,634

Panel B2: Period II - After Lehman Brothers Bankruptcy (09.16.2008 - 12.31.2018)

Cross-currency swap Basis Points	Per. II - After Lehman Brothers Bankruptcy				
	Mean	SD	Min	Max	N
Australian dollar	12.77	7.62	(71.00)	40.00	2,706
Canadian dollar	(9.08)	11.48	(37.50)	37.00	2,705
Swiss Franc	(28.29)	13.19	(82.13)	(6.00)	2,707
British Pound	(12.22)	14.42	(116.60)	11.60	2,704
Singaporean dollar	(3.70)	3.84	(35.00)	9.73	2,696

Source: Calculated by the author.

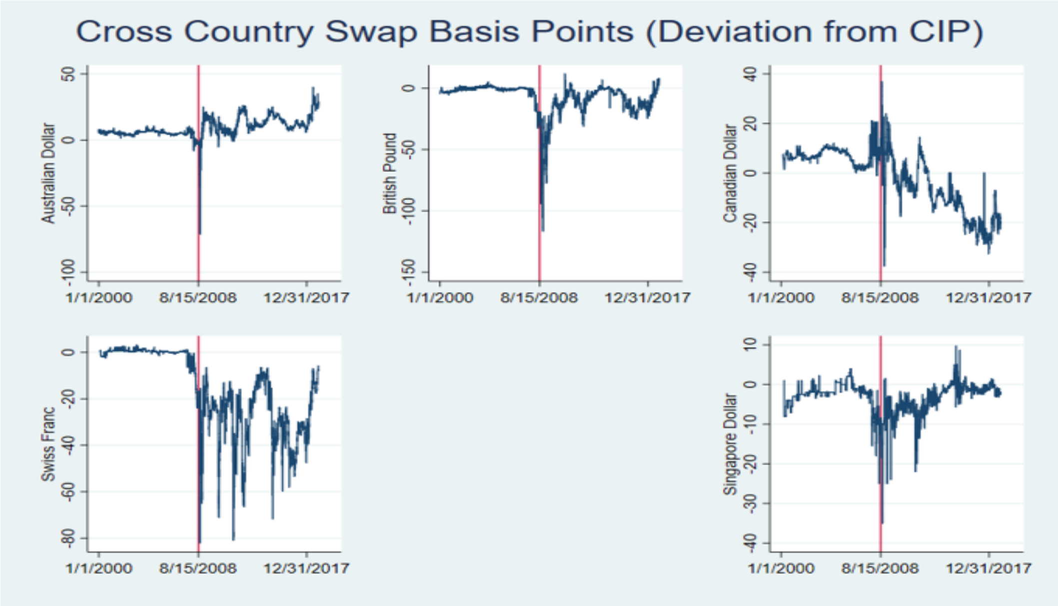


Figure 3.3.2: Source: Elaborated by the author.

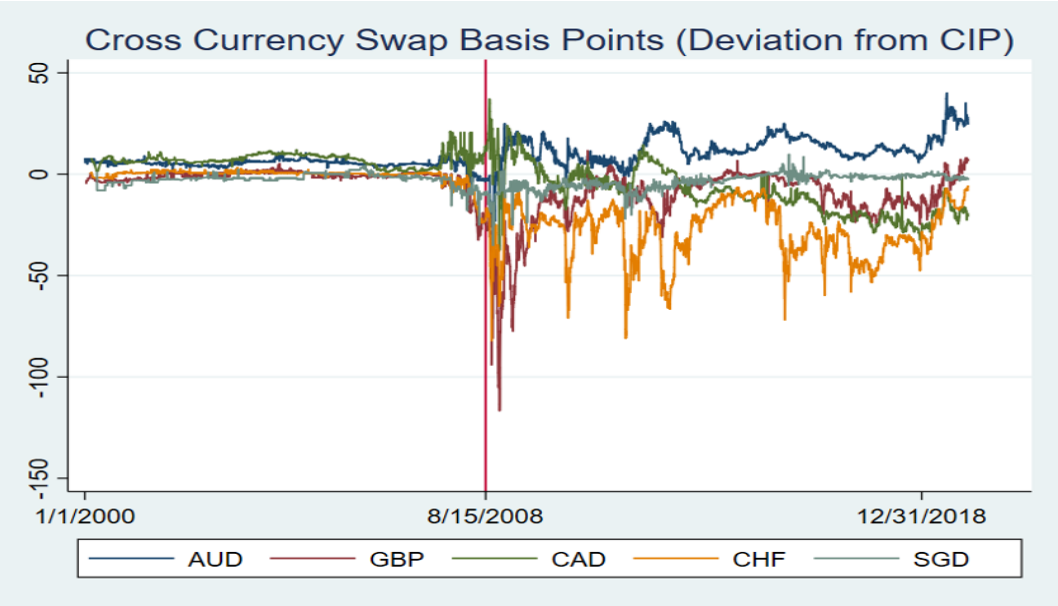


Figure 3.3.3: Source: Elaborated by the author.

From table 3 we can see a significant change in the deviation from the covered interest rate parity for these currencies. The increase is observed not only in the mean basis, but also in their volatilities. The only exception is seen over the Singaporean dollar (SGD), which has a somehow stable standard deviation on the basis (but still with a rise in the mean).

The additional variables presented in the literature review and which will compose the regression analysis, are explained below.

Liquidity proxies

The liquidity proxies used are the spread over the exchange rate spot and the spread over the exchange rate future contract. The first is the difference between the prices quoted for an immediate sale (offer) and an immediate purchase (bid) for the spot exchange rate. The latter is the difference between the prices quoted for an immediate sale (offer) and an immediate purchase (bid) for future exchange-rate contracts. The data for both these variables was collected on Bloomberg.

Risk proxy

The risk proxy used in this paper and based in the literature is the average CDS (Credit Default Swap) of the G-Sibs (Global Sistemically important banks). I have selected the list of thirty banks defined by the Financial Stability Board (FSB) and have calculated their average premium. Ideally, it should obtain a measure of risk for these institutions that are responsible for intermediating the swap trades. The banks defined as G-Sibs by the FSB are available at table A1.

Financial Market and Macro Variables

Regarding financial market and macroeconomic variables, I have used Terms of Trade, Bank concentration and VIX. The terms of trade is a widely used measure in the literature. It is defined as the ratio of export prices to import prices, and it can be defined as the amount of import goods an economy can purchase per unit of export goods. It is used in this paper as a context for demand for USD, and its information was obtained on Bloomberg. The Bank Concentration is calculated by the World Bank. It measures the weight of the five largest banks in the country (by assets).

The Volatility Index (VIX) measures of the stock market's expectation of volatility implied by S&P 500 index options, calculated and published by the Chicago Board Options Exchange (CBOE). It is a widely used measure of global risk and its data was also obtained on Bloomberg.

3.4 Results

3.4.1 Shifts and Regressions

A primary and simple check regarding the impact of the Lehman Brothers bankruptcy over the deviations from CIP was done through a t-test and mean comparison between the two periods. Despite a illustrative representation of the different behaviors through figures 2 and 3, a formal test is conducted, with its results available on table 5.

Table 3.4.1: T-tests for mean differences pre x post Lehman

	Difference	Std. Error	N (pre-Lehman)	N (post-Lehman)
Australian dollar	-7.5843***	0.1658	2230	2706
Canadian dollar	16.1801***	0.2615	2041	2705
Swiss Franc	27.6028***	0.3084	1959	2707
British Pound	10.5057***	0.3336	2021	2704
Singaporean dollar	1.2399***	0.1119	1634	2696

Source: Elaborated by the author.

Tables 6-10 compile the regressions for all currencies having the basis as the dependent variable and the statistical significance of each independent variable described on sections 3.1.2 - 3.1.4, added accordingly to its economic meaning and relation to the literature.

Additionally, I added a dummy for post crisis period (September 15th, 2008, the Lehman Bank bankruptcy). This dummy represents a fixed effect for pre and post period, allowing me to control for unobservable differences in CIP before and after crisis. There was a concern regarding the scenario where CIP was just at a different level after the crisis for reasons not captured by the regressors, indicating the necessity of time fixed effect control for it. As the data has daily frequency not only on the dependent variable, but also in the regressors, this was ruled out. As I am looking for the potential changes in the relationship between the explanatory variables and CIP during the crisis, then I will look for the interaction among dummies and regressors for pre and post crisis periods. For illustration purposes, I will also add the regressions without the dummies. I will start with a baseline model (regressions 1 and 3), which contemplates most used liquidity variables – spread for spot and future contracts and terms of trade. Additionally, I will evaluate an extended model, which will embrace also other variables used as possible drivers for deviation on CIP, like Bank concentration, average CDS premia for global systemically important banks, and global volatility index (regressions 2 and 4). Both models were added on a lagged term for the dependent variable.

The regressions assume the form:

$$CCS_t = \beta_0 + \beta_1 \times Spot_t + \beta_2 \times Future_t + \beta_3 \times TOT_t + \beta_4 \times CCS_{t-1} \quad (3.4.1)$$

$$CCS_t = \beta_0 + \beta_1 \times Spot_t + \beta_2 \times Future_t + \beta_3 \times TOT_t + \beta_4 \times BC_t + \beta_5 \times CDS_t + \beta_6 \times VIX_t + \beta_7 \times CCS_{t-1} \quad (3.4.2)$$

$$CCS_t = \beta_0 + \beta_1 \times Spot_t + \beta_2 \times Future_t + \beta_3 \times TOT_t + \beta_4 \times D \times Spot_t + \beta_5 \times D \times Future_t + \beta_6 \times D \times TOT_t + \beta_7 \times D + \beta_8 \times CCS_{t-1} \quad (3.4.3)$$

$$CCS_t = \beta_0 + \beta_1 \times Spot_t + \beta_2 \times Future_t + \beta_3 \times TOT_t + \beta_4 \times D \times Spot_t + \beta_5 \times D \times Future_t + \beta_6 \times D \times TOT_t + \beta_7 \times BC_t + \beta_8 \times CDS_t + \beta_9 \times VIX_t + \beta_{10} \times D \times BC_t + \beta_{11} \times D \times CDS_t + \beta_{12} \times D \times VIX_t + \beta_{13} \times D + \beta_{14} \times CCS_{t-1} \quad (3.4.4)$$

Where:

- CCS – Cross-currency swap basis points
- Spot – Spread spot (section 3.1.2)

• Future – Spread future (section 3.1.2)

• TOT – Terms of trade (section 3.1.4)

• D – dummy for the period related to the Lehman Brothers bankruptcy (D = 0 before the event, and D = 1 after the event).

• BC – Bank concentration (section 3.1.4)

• CDS – Average of GSIBs CDS (section 3.1.3)

• VIX – Volatility index (section 3.1.4)

• CCS_{t-1} – lagged cross-currency swap basis points

The regression results are presented on tables 6-10. The economic intuition of an increase on the cross-currency swap basis points (taken as the proxy for the deviation of covered interest rate parity) implies that its related to a decrease in market liquidity. This was expected to be seen or correlated with an increase in the spread of both spot and future contracts. The term of trade variable is defined as the ratio of exports over imports. This means that an increase in it implies a smaller necessity of US dollars, and an improvement on the liquidity. That said, it is expected that terms of trade would be negatively related with the cross-currency basis.

The group of variables added on regressions (2) and (4) – bank concentration, average CDS for G-Sibs and VIX – is expected to be related to the basis in the following fashion.

As the trades for cross currency swaps are mostly over-the-counter trades, they are conducted through banks, and not by the brokerage firms directly on exchange houses (like NYSE, CBOE, for example). If a local firm is willing to do a cross-currency swap and its local financial system is more concentrated, i.e., offer less options for this firm, it is expected that the basis for the operation would be higher. The hypothesis for this variable is that it is positively related with the CIP deviation.

As the CDS is a security against the default for any specific asset issuer, the G-Sibs average CDS evaluates how the market is pricing the risk of these financial institutions to not honor their operations. The higher the CDS premium for this group pf banks, less confident the clients will be to conduct transactions with, implying a positive relation with CIP deviation. On the other hand, there is an argument that this lack of confidence on these banks would contribute for their lower rates, increasing the number of operations. We see that there are arguments on both directions, and the regressions will help to clarify which one (if any) prevails.

VIX is the S&P 500 Volatility Index – a largely used measure of stocks' market volatility. Its increase is expected to widen the basis of cross-currency swaps.

The table below summarizes the hypothesis for the variable directions.

Table 3.4.2: Direction hypothesis for the dependent variables

	Dep. Variables	Independent Variables					
Cuurency	Basis	Spot	Future	Terms of Trade	Bank Concentration	Average G-Sibs CDS	VIX
(direct quotation)	↓	↓	↓	↑	↓	Undefined	↓

Source: Elaborated by the author.

It is important to note that the Australian dollar goes in the opposite direction of all the other currencies due to the form it is quoted in the market. To circumvent that, I have transformed the AUD/USD quotation, i.e., the amount of US dollar required to buy one Australian dollar, to USD/AUD, the amount of Australian dollars to buy one US dollar.

Baseline - Regressions (1) and (2)

The baseline cases, regressions (1) and (2) contemplates the whole period without a dummy variable for the period after Global Financial Crisis. The addition of the second group of control variables (regression 2) doesn't' change neither the significance not the signs of the coefficients for the first regression (1). The only exception is for the Canadian dollar, which start having the terms of trade as significant on regression 2, in contrast to regression 1.

Regarding the expected signs, the results are mixed. The spot spread has the hypothesized sign for all currencies, besides GBP, although none of it are significant. The future spread has the hypothesized sign only for AUD dollar and CHF, with only CAD and CHF significant. This means that these variables are weakly explanatory in this set-up. For the terms of trade, the coefficients are significant for all currencies, despite AUD. Nevertheless, the only expected sign is for the GBP.

Extended Regressions (3) and (4)

The comparison between regressions (3) and (4) is similar as the one done above – (1) and (2), with the shift for the post-GFC considered. When the second group of independent variables are considered, the interaction term with future spread loses significance for the AUD and gain significance for the SGD. All other coefficients for the first block are the same in terms of significance.

Regarding the expected signs hypothesized on table 5, the results are also far for conclusion. While AUD matches the expected signs, all other currencies show deviances from it (CAD shows divergence is spot and future spread, as well as terms of trade; CHF shows divergence on future spread, terms of trade, and VIX; GBP shows divergence on VIX; and SGD shows divergence on future spread, terms of trade, bank concentration and VIX).

The most complete set-up – Regression (4)

This section focuses mostly on the most complete set-up, i.e., regression (4). For the five countries evaluated (tables 6-10), only UK and Singapore (tables 9 and 10) show a significant result for the second group of interactions - bank concentration, average CDS of G-Sibs and VIX. The bank concentration coefficient shows opposite signs for these two countries, weakening its interpretation. In a set of five countries, three don't show significance, and the two other present conflicted intuition. It definitely suggests some deeper analysis and treatment to understand how it is related to the deviations from CIP, and also puts a yellow sign before using it as a channel for a theoretical model.

Regarding the average CDS of G-Sibs, it was discussed above how both signs for the coefficient could have an economic interpretation. The empirical results for the regression over UK and Singapore show consistency in the positive sign, suggesting that the increase in the risk perception for these banks widens the basis.

For the VIX, the results shown for both UK and Singapore are also consistent with the hypothesis: a larger volatility implies a higher risk perception, which correlates with an increase in the basis / deviation from CIP. Even though the results are satisfactory for two out of three variables for UK and Singapore, it is interesting to explore a deeper institutional country analysis in order to identify why these variables are not significant for Australia, Canada, and Switzerland. In some degree, we can say that the results suggest the financial and macro variables as highly correlated with this new scenario of deviation from CIP. The cause for the Singapore result might be caused by its particular degree of freedom over its financial market, which caused less risk aversion over its currency.

Regarding the spot and future spread, the results are mixed. Australian dollar and Canadian dollar show no correlation, while swiss franc show significance only in the future spread, the British Pound show significance (at 10% level) only for the spot spread, and the Singaporean dollar show significance in both spot and future spread.

The significance on terms of trade (Australian dollar and Canadian dollar) can be an indication of the real export channel getting higher weight through this period.

The lack of significance of the bid-ask spread for spot and/or future markets for some currencies is intriguing. The increase of CIP post GFC has as one of main hypothesis the liquidity constraint. Also, one of the most practiced proxies for liquidity concerns the bid-ask spread. Nevertheless, we see that the significance over the interaction with the post-Lehman dummy is present over independent variables with institutional characteristics, like terms of trade and bank concentration, and global factors, like VIX and the CDS premium of G-Sibs (UK and Singapore). This fact raises questions about the proper intervention policies from the regulators.

For example, one of the first responses from the Fed to the crisis was the incentive to some mergers in order to absorb the more problematic banks. It's noteworthy that the main idea was to "stop the bleeding" and avoid bank-runs through all the system, but this result try to shed light about the cost of a higher bank concentration as a narrower set of institutions to channel the liquidity to the real economy.

Regarding the VIX and the G-Sibs CDS (British Pound and Singaporean dollar), the main lesson provided by this result was well explored: the lack of regulation and criteria from regulatory agencies, supposed to supervise the financial institutions, contributed to the increase on leverage and risk profile for all the major banks.

Table 3.4.3: Australian dollar Cross-Currency Swaps regressions

	(1)	(2)	(3)	(4)
Variables	AUD_CCS	AUD_CCS	AUD_CCS	AUD_CCS
Spot spread	5.911	6.554	-0.516	-0.636
	(3.954)	(4.241)	(1.182)	(1.42)
Future spread	0.0257	0.0702	-0.005	-0.00161
	(0.0325)	(0.0705)	(0.00626)	(0.00678)
Terms of trade	-0.000124	-0.00284	-0.00171	0.000953
	(0.00145)	(0.00213)	(0.00133)	(0.00219)
D * (Spot spread)			9.203	9.323
			(6.109)	(6.236)
D * (Future spread)			0.383*	0.252
			(0.233)	(0.276)
D * (Terms of trade)			-0.00560*	-0.00717*
			(0.003)	(0.00417)
Bank Concentration		0.00723		0.00495
		(0.00604)		(0.00494)
Average CDS G-Sibs		0.00189		-0.00407
		(0.00126)		(0.0031)
VIX		-0.0107		0.00606
		(0.00736)		(0.00603)
D * (Bank Concentration)				0.0673
				(0.0558)
D * (Average CDS G-Sibs)				0.00569
				(0.00365)
D * (VIX)				-0.00886
				(0.0144)
Lag – CCS	0.981***	0.973***	0.968***	0.955***
	(0.0151)	(0.0185)	(0.0238)	(0.0304)
D			0.402	-5.83
			(0.258)	(5.16)
Constant	0.182	-0.281	0.175	-0.242
	(0.138)	(0.506)	(0.131)	(0.389)
Observations	4757	4335	4757	4335
R-squared	0.963	0.962	0.963	0.962

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 3.4.4: Canadian dollar Cross-Currency Swaps regressions

	(1)	(2)	(3)	(4)
Variables	CAD_CCS	CAD_CCS	CAD_CCS	CAD_CCS
Spot spread	67.23	49.94	92.72	33.04
	(98.63)	(133.1)	(146.5)	(156.9)
Future spread	-0.000768***	-0.000721***	-0.000600***	-0.000420***
	(0.000211)	(0.000209)	(0.000155)	(0.000159)
Terms of trade	0.00735	0.0176**	0.00165	-0.0122
	(0.00502)	(0.00861)	(0.0091)	(0.0121)
D * (Spot spread)			-19.13	-36.78
			(181.4)	(214.1)
D * (Future spread)			-0.00425	-0.000337
			(0.0202)	(0.0187)
D * (Terms of trade)			0.0291**	0.0586***
			(0.0135)	(0.02)
Bank Concentration		0.00758		0.0249***
		(0.00587)		(0.00916)
Average CDS G-Sibs		-0.00119*		0.00169
		(0.000688)		(0.00406)
VIX		0.0124		0.00445
		(0.00879)		(0.00986)
D * (Bank Concentration)				0.00346
				(0.0121)
D * (Average CDS G-Sibs)				0.00244
				(0.00424)
D * (VIX)				0.00543
				(0.0156)
Lag – CCS	0.990***	0.984***	0.978***	0.955***
	(0.00272)	(0.00458)	(0.00559)	(0.0102)
D			-0.554***	-1.817*
			(0.174)	(1.01)
Constant	-0.0888**	-0.988*	0.128	-1.955***
	(0.0431)	(0.594)	(0.0838)	(0.744)
Observations	4570	4298	4570	4298
R-squared	0.981	0.981	0.982	0.981

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 3.4.5: Swiss Franc Cross-Currency Swaps regressions

	(1)	(2)	(3)	(4)
Variables	CHF_CCS	CHF_CCS	CHF_CCS	CHF_CCS
Spot spread	72.38	109.5	-18.39	50.98
	(57.89)	(68.47)	(79.45)	(97.75)
Future spread	-0.00229**	-0.00257***	-0.00222	-0.00233**
	(0.00104)	(0.000527)	(0.00151)	(0.00094)
Terms of trade	0.0167**	0.0351***	0.0193***	0.0263***
	(0.00657)	(0.0126)	(0.00733)	(0.0092)
D * (Spot spread)			114.1	67.36
			(99.2)	(120.3)
D * (Future spread)			-2.134**	-3.254***
			(0.866)	(0.907)
D * (Terms of trade)			-0.012	0.0594
			(0.045)	(0.0847)
Bank Concentration		0.0734***		0.0235
		(0.0191)		(0.0195)
Average CDS G-Sibs		-0.00298**		-0.00291
		(0.00133)		(0.00205)
VIX		-0.00959		0.000695
		(0.00833)		(0.00543)
D * (Bank Concentration)				0.0518
				(0.0356)
D * (Average CDS G-Sibs)				0.000355
				(0.00247)
D * (VIX)				-0.0228
				(0.0169)
Lag – CCS	0.993***	0.976***	0.983***	0.972***
	(0.00316)	(0.00649)	(0.00662)	(0.00753)
D			-0.693	-4.376
			(0.472)	(2.706)
Constant	-0.0207	-6.453***	0.0836**	-2.008
	(0.0413)	(1.742)	(0.0405)	(1.83)
Observations	4470	4193	4470	4193
R-squared	0.988	0.988	0.988	0.988

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 3.4.6: British Pound Cross-Currency Swaps regressions

Variables	(1) GBP_CCS	(2) GBP_CCS	(3) GBP_CCS	(4) GBP_CCS
Spot spread	-7.495	-38.14	-5.415	-5.805
	(54.8)	(33.69)	(4.411)	(4.382)
Future spread	0.303	0.0687	-0.233	-0.226
	(0.456)	(0.177)	(0.146)	(0.141)
Terms of trade	-1.795***	-1.988***	-0.0239	-0.0392**
	(0.0718)	(0.101)	(0.0146)	(0.0177)
D * (Spot spread)			27.90*	26.73*
			(14.38)	(14.31)
D * (Future spread)			0.247	0.244
			(0.155)	(0.15)
D * (Terms of trade)			0.130**	-0.0283
			(0.056)	(0.0895)
Bank Concentration		-0.0814***		0.000711
		(0.0155)		(0.00211)
Average CDS G-Sibs		-0.0413***		-0.00735**
		(0.00485)		(0.00294)
VIX		-0.788***		0.00753
		(0.0451)		(0.00662)
D * (Bank Concentration)				0.0574***
				(0.0216)
D * (Average CDS G-Sibs)				0.00632**
				(0.00315)
D * (VIX)				-0.0577***
				(0.0193)
Lag – CCS	0.303***	0.164***	0.985***	0.966***
	(0.0494)	(0.0318)	(0.00874)	(0.00971)
D			-1.033**	-3.201
			(0.438)	(1.95)
Constant	-0.147	26.61***	0.0595	0.121
	(0.247)	(1.628)	(0.0475)	(0.193)
Observations	4594	4248	4495	4197
R-squared	0.096	0.508	0.978	0.978

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 3.4.7: Singaporean dollar Cross-Currency Swaps regressions

Variables	(1) SGD_CCS	(2) SGD_CCS	(3) SGD_CCS	(4) SGD_CCS
Spot spread	0.26	0.862	-261.5***	-363.9***
	(19.13)	(22.3)	(94.98)	(138.1)
Future spread	-0.000353	-0.000505	0.0285	0.0531**
	(0.000816)	(0.000695)	(0.0187)	(0.0232)
Terms of trade	0.0320***	0.0478***	0.0236**	0.0179
	(0.00748)	(0.00987)	(0.01)	(0.0186)
D * (Spot spread)			267.7***	372.8***
			(95.65)	(138.8)
D * (Future spread)			-0.0288	-0.0537**
			(0.0187)	(0.0232)
D * (Terms of trade)			0.0159	0.0164
			(0.0122)	(0.0202)
Bank Concentration		-0.0600***		0.0292
		(0.0126)		(0.039)
Average CDS G-Sibs		-0.00430***		-0.0192***
		(0.000854)		(0.00394)
VIX		-0.0237***		-0.0033
		(0.00638)		(0.00778)
D * (Bank Concentration)				-0.140***
				(0.0506)
D * (Average CDS G-Sibs)				0.0146***
				(0.0038)
D * (VIX)				-0.0184*
				(0.0103)
Lag – CCS	0.916***	0.826***	0.914***	0.807***
	(0.0189)	(0.0284)	(0.0193)	(0.0305)
D			0.0125	13.57***
			(0.0835)	(4.964)
Constant	-0.0336	6.384***	-0.00146	-2.495
	(0.033)	(1.267)	(0.0615)	(3.933)
Observations	4058	3895	4058	3895
R-squared	0.875	0.882	0.875	0.883

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

3.4.2 Some extensions

To improve the power of the results, I have also run a panel analysis for the data to observe how would that differ from the cross countries results (without the lagged variables). They are available on table 11 and show similar results from the cross-country analysis.

Table 3.4.8: Cross-currency Swaps panel regressions

Variables	(1) CCS	(2) CCS
Spot spread	-9.519	-15.13**
	(8.113)	(6.92)
Future spread	0.0371	0.0154
	(0.0528)	(0.0254)
Terms of trade	0.116***	0.186***
	(0.00559)	(0.00483)
D * (Spot spread)	-7.103	-28.63
	(27.32)	(23.55)
D * (Future spread)	-0.029	0.000059
	(0.054)	(0.0274)
D * (Terms of trade)	0.491***	0.465***
	(0.0107)	(0.0101)
Bank Concentration		0.0851***
		(0.00283)
Average CDS G-Sibs		-0.151***
		(0.00563)
VIX		0.328***
		(0.0116)
D * (Bank Concentration)		0.425***
		(0.0104)
D * (Average CDS G-Sibs)		0.140***
		(0.00629)
D * (VIX)		-0.487***
		(0.023)
D	-11.64***	-41.26***
	(0.128)	(0.866)
Constant	1.980***	-7.783***
	(0.0514)	(0.305)
Observations	27350	25231
R-squared	0.311	0.398

Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

As a frequent argument in the literature about the deviation from CIP resides on the lack of liquidity for the markets, I have checked how the Cross-country swap basis points behaved for the same six pairs of currencies for the period around the Quantitative Easing. I have run the same t-test for the means, but now comparing the QE1 and QE2 announcements dates, and also for a smaller window – two weeks before and two weeks after the announcement (tables 12 and 13).

Table 3.4.9: T-tests for mean differences pre x post QE1

	Difference	Std. Error	N (pre-QE1)	N (post-QE1)
Australian dollar	-6.8956***	1.0737	15	17
Canadian dollar	21.8926***	6.1024	15	17
Swiss Franc	11.6559***	3.6944	15	17
British Pound	0.6838	9.3846	15	17
Singaporean dollar	-6.6382***	1.2344	15	17

Source: Elaborated by the author. The QE1 date was Nov 25, 2008.

Table 3.4.10: T-tests for mean differences pre x post QE2

	Difference	Std. Error	N (pre-QE2)	N (post-QE2)
Australian dollar	1.3836**	0.5211	22	23
Canadian dollar	-0.6337	0.6828	22	23
Swiss Franc	2.3772***	0.5815	22	23
British Pound	0.224	0.2979	22	23
Singaporean dollar	0.3549	0.3927	22	23

Source: Elaborated by the author. The QE2 date was Aug 10, 2010.

The weaker results, with some currencies showing no difference in their means between the periods, is consistent with the idea that market liquidity is not the main driver for the deviation of CIP. The period of analysis for the change due to specific event (the QE announcements) was chosen to be small in an attempt to isolate its effect over the deviation from CIP. If extended to a larger period, the effect would be probably be impacted from other market variables as well. That said, the regressions for these window were not reproduced due to the small dataset and limited explanation power. This limitation raises a possibility for a future study with intraday data around the QE announcements.

3.5 Final Remarks

In this paper, I have empirically conducted an evaluation over the deviation from covered interest rate parity. Through an extensive literature review, I have mapped possible drivers for explaining the failure of the no arbitrage condition in the foreign exchange market after the great financial crisis. I have also extended the analysis for a set of countries not explored in the literature despite having a significant weight in the FX market. I have obtained results that claim for a larger reason for the deviation than only liquidity constraints, which open channels for further empirical analysis as well as different channels for theoretical proposals on monetary policies models. The lack of consistency of some drivers discussed in the literature when evaluated in a cross-country set-up raises a question of how important institutional characteristics of a country are when evaluating its deviation from CIP. Despite the rise in the deviation from the CIP being a real fact obtained through the empirical observations, its mechanisms are still not clear enough. This is an important contribution for the theoretical developments aiming to absorb the failure to no arbitrage condition in their models.

3.6 References

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3.7 Appendix

Table 3.7.1: G-Sibs defined by Financial Stability Board

JP Morgan Chase	Bank of China	Ind. and Comm. Bank of China Lim.
Bank of America	Barclays	Mitsubishi UFJ FG
Citigroup	BNP Paribas	Wells Fargo
Deutsche Bank	China Construction Bank	Agricultural Bank of China
HSBC	Goldman Sachs	Bank of New York Mellon
Nordea	Standard Chartered	Credit Suisse
Royal Bank of Canada	State Street	Groupe Crédit Agricole
Royal Bank of Scotland	Sumitomo Mitsui FG	ING Bank
Santander	UBS	Mizuho FG
Société Générale	Morgan Stanley	

Source: Financial Stability Board